Greenhouse Gas Emissions Inventory

Philadelphia International Airport
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PHL PHILADELPHIA INTERNATIONAL AIRPORT

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Contents

Executive Summary

ES.1 Objective

This greenhouse gas (GHG) emissions inventory was completed for Philadelphia International Airport (PHL) for the year 2013. The main objective of the inventory is to assist PHL with identifying, quantifying, and managing the Airport's emissions of GHGs in accordance with its commitment to environmental stewardship.[1]

The inventory was prepared following guidance established by the U.S. Environmental Protection Agency (USEPA), the Intergovernmental Panel on Climate Change (IPCC), and the Energy Information Administration (EIA). The assessment also utilized guidance produced by the Transportation Research Board (TRB) Airport Cooperative Research Program (ACRP). The most up-to-date operational data and other information specific to PHL representing 2013 conditions were used to the fullest extent possible.

ES.2 Summary of Results

The 2013 GHG emissions inventory for PHL is summarized in **Table ES-1.** This table lists emissions by planning categories, which indicate the ownership and control of each source by the Airport, tenants, and the public. Consistent with the IPCC guidelines, this emissions inventory addresses the 3 primary GHGs identified in the Kyoto Protocol[2]: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O). The remaining 3 types of Kyoto GHGs, hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6), occur at airports – from refrigeration and air-conditioning usage – but to a far lesser extent. The results are reported in units of metric tons (MT) of carbon dioxide equivalents (CO_{2e}) on an annual basis.

As shown in **Table ES-1**, GHG emissions associated with Category 2 (Airport Tenant) – specifically, aircraft engine emissions – are by far the highest emitting sources at the Airport. Motor vehicles across all 3 categories are the second-highest emitting sources. Of note, Airport-owned and controlled sources (Category 1) comprise only 2 percent of the total GHG emissions.

[1] A GHG emissions inventory was previously conducted for PHL in June 2009, using a baseline year of 2006, http://www.phl.org/AboutPHL/Environmentalinitiatives/SustainabilityInitiatives/Documents/GHGinventoryFinalSH.pdf. Also see the PHL Environmental Stewardship Plan at: http://www.phl.org/AboutPHL/Environmentalinitiatives/Documents/PHL%20Envtal%20Stewardship%20Plan%20Oct08.pdf.

[2] The Kyoto Protocol is an international agreement linked to the United Nations Framework Convention on Climate Change (UNFCCC). The primary directive of the Kyoto Protocol is that it sets binding targets for 37 industrialized countries (of which the U.S. is a signatory, but has not yet ratified the Protocol) and the European community to limit their emissions of the 6 greenhouse gases (i.e., carbon dioxide, methane, nitrous oxide, hydrofluorocarbons, perfluorocarbons, and sulfur hexafluoride).

Table ES-1. PHL GHG Emissions Inventory for 2013

Planning Category	Emission Source	MT CO_{2e}
Category 1 – Airport	Electrical Usage	40,440
	GAV[1]	35,752
	Stationary Sources	18,474
	Contracted Shuttles	1,780
	Construction	1,282
	GSE[2]	1,046
	Refrigerants	147
	Fire Training Facility	112
	Subtotal	**99,033 (2%)**
Category 2 – Tenant	Aircraft[3]	3,885,320
	GAV[4]	162,687
	Electrical Usage	36,030
	GSE[5]	16,339
	APU	9,366
	Aircraft Engine Startup	2,546
	Contracted Shuttles	2,371
	Subtotal	**4,114,659 (92%)**
Category 3 – Public	GAV[6]	229,555
	SEPTA Public Transit[7]	31,779
	Subtotal	**261,335 (6%)**
	Total[8]	**4,475,027 (100%)**

Notes: **APU** – Auxiliary Power Unit, **GAV** – Ground Access Vehicles, **GSE** – Ground Support Equipment, and **SEPTA** – Southeastern Pennsylvania Transportation Authority.

1. GAV include airport fleet vehicles and employee vehicles traveling within parking facilities, and vehicles traveling on-airport roadways.
2. GSE includes only airport snow removal equipment.
3. Aircraft includes taxi, above the ground to 3,000 feet and cruise mode to destination.
4. GAV include tenant fleet vehicles traveling within parking facilities and on both on- and off-airport roadways.
5. GSE includes tenant operated equipment such as belt loaders, baggage tractors, etc.
6. GAV include passenger vehicles traveling off-airport roadways.
7. SEPTA public transit includes those commuter rail and bus routes servicing the airport.
8. Values may reflect rounding.

For ease of comparison, the results are also presented graphically by each planning category in **Figures ES-1 through ES-3**. Whereas Category 1 emissions only comprise 2 percent of the total GHG inventory, Categories 2 and 3 comprise 92 percent and 6 percent of GHG emissions, respectively.

Figure ES-1. Category 1 - Airport GHG Emissions (CO_{2e})

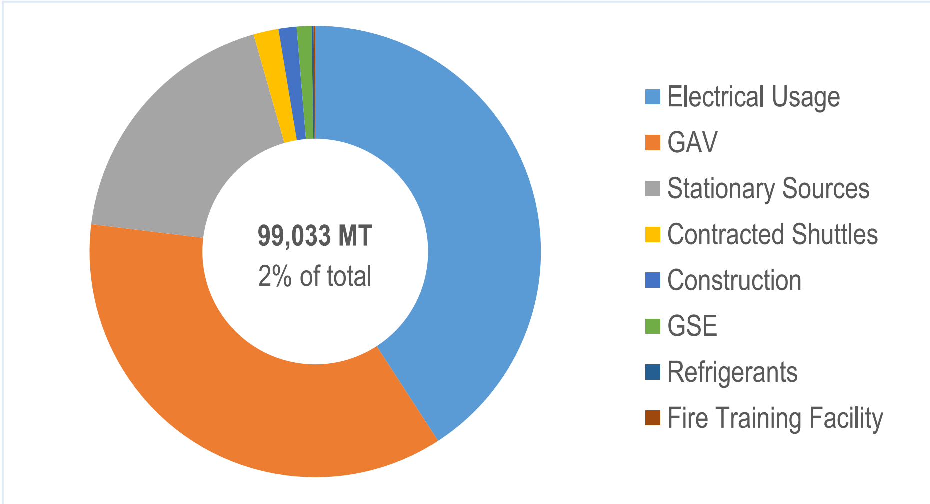


Figure ES-2. Category 2 - Tenant GHG Emissions (CO_{2e})

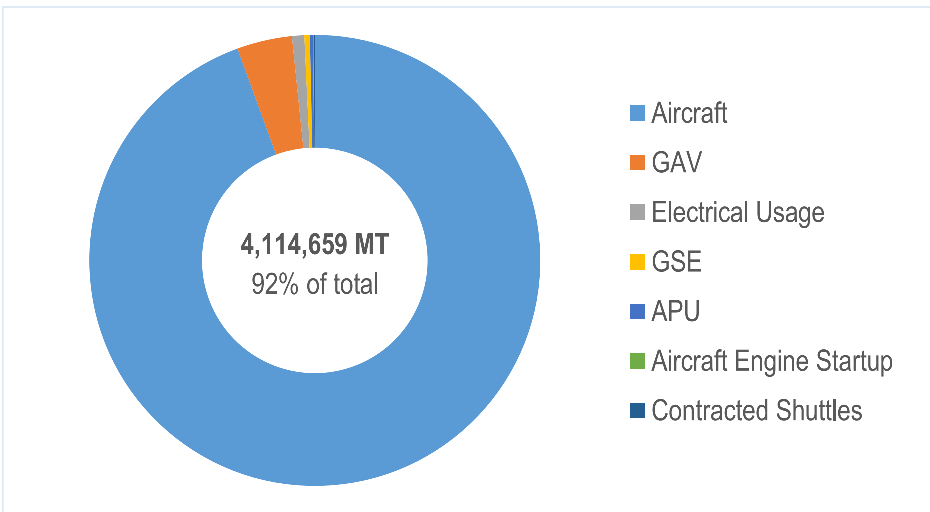
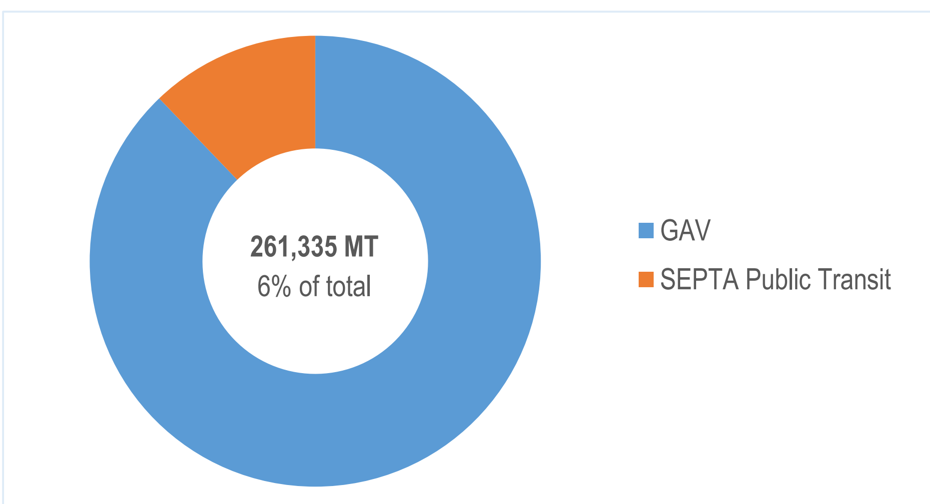


Figure ES-3. Category 3 - Public GHG Emissions (CO_{2e})



In 2013, PHL reduced its GHG emissions by 5,820 MT CO_{2e} as a result of waste management practices, by diverting materials from the landfill through recycling initiatives by the tenants and Airport (the Airport recycled a total of approximately 1,817 tons of material and sent 7,775 tons of material to the landfill).[3,4] Furthermore, compared to the Airport's previous 2006 GHG emissions inventory, the 2013 inventory shows an overall reduction in GHG emissions of approximately two percent.

ES.3 Emissions Reduction Initiatives

Over the past several years, PHL has initiated a number of emission reduction measures, including those that impact GHGs. A summary of these on-going efforts at PHL are listed below.

- Purchase of hybrid vehicles.
- Installation of pre-conditioned air and 400 Hertz (Hz) power at over 90 percent of aircraft gates.
- Purchase and installation of electric ground support equipment (GSE) charging stations.
- Implementation of Energy Conservation Measures (ECMs).
- Improvements to ground transportation.
- Implementation of the Recycling Program and Recycling Committee.
- Implementation of the Waste Reduction Program.
- Requirement for new/renovated buildings over 10,000 square feet to meet Leadership in Energy & Environmental Design (LEED) Silver standard.
- Installation of interior and exterior light-emitting diode (LED) lighting, including airfield lighting.
- Installation of a compressed natural gas (CNG) station at WallyPark (off-airport parking) and purchase of CNG shuttle fleet.

As part of this GHG emissions inventory, a list of potential emissions reduction initiatives were identified and qualitatively evaluated for future consideration. These included waste management, transportation, facilities, airside, and planning measures which are summarized below.

- Additional waste management practices, such as an expansion of the Airport's recycling program to include food waste and construction and debris materials.
- Transportation initiatives, such as Airport fleet vehicle improvements and incentives for tenants and the public to use alternative fuel vehicles.
- A variety of potential facility improvements, to reduce energy use in existing facilities and to maximize the benefit of new facilities.
- Operational improvements on the airside such as single-engine aircraft taxiing.
- Planning measures aimed at sustainability activities and GHG registries.

PHL hopes to implement programs that relate to these initiatives in future years.

[3] As compared to a scenario in which all waste is landfilled. See Appendix C for further details on waste management reduction emission calculations.

[4] Emissions estimates based on data available from the City of Philadelphia's Division of Aviation (DOA), US Airways, and Marketplace Philadelphia. Recycling quantities are not inclusive of all tenants at PHL.

1 Introduction

1.1 Motivation and Purpose for this Update

There is presently a broad scientific consensus that greenhouse gases (GHG) associated with human activities are contributing to changes in the earth's atmosphere. These GHGs, brought about principally by the combustion of fossil fuels, decomposition of waste materials, changes in land uses, and deforestation, are linked to an increase in the earth's average temperature by means of a phenomenon called the "greenhouse effect".[5]

Aerial View of Philadelphia International Airport

As GHG emissions from human activities increase, they contribute to the greenhouse effect and warming of the climate, which in turn leads to other changes in the atmosphere, on land, and in the oceans. These changes have potential for both positive and negative effects on humans, plants, and animals. Because many GHGs remain in the atmosphere for tens to hundreds of years after being released, their warming effectson the climate could become long-lasting.

With the growing concern of climate change and the potential impacts on airports, Philadelphia International Airport (PHL) is commited to addressing this issue. PHL conducted its first GHG emission inventory in 2009 using 2006 as baseline year.[6] The purpose of this updated 2013 GHG emissions inventory is to:

- Identify the principal sources of GHGs associated with the operation of the Airport;
- Quantify GHG emissions under current conditions; and
- Help guide the development of initiatives to manage and reduce GHG emissions.

PHL is among numerous airports nationwide that are undertaking proactive efforts to manage GHGs associated with their facilities. These assessments have been initiated despite evidence that aviation accounts for only 11 percent of all transportation-related CO_2 emissions worldwide.[7]

[5] The phenomenon whereby certain gases in the atmosphere, primarily carbon dioxide, water vapor, and methane, allow incoming sunlight to pass through, but trap, absorb, and retain heat radiated back from the earth's surface.

[6] Philadelphia International Airport, Greenhouse Gas Emissions Inventory, Final Report June 2009, http://www.phl.org/AboutPHL/Environmentalinitiatives/SustainabilityInitiatives/Documents/GHGinventoryFinalSH.pdf.

[7] ICAO Environment Report 2010: Aviation and Climate Change. Montréal: International Civil Aviation Organization, 2010.

1.2 Approach and Methodology

Consistent with the prevailing approaches to quantifying GHGs, the overall approach to conducting the 2013 GHG emissions inventory for PHL followed 6 guiding principles:

- *Accurac*y – Use of the most up-to-date available data and application of reasonable assumptions in order to reduce uncertainties as much as practicable.
- *Completeness* – Include all relevant and available information that may significantly affect the accounting and quantification of GHG emissions at PHL.
- *Conservativeness* – Estimate GHG emissions on the "high side" to ensure that GHG emission reductions are not overstated.
- *Consistency* – Use the most appropriate guidelines for quantifying airport-related emissions.
- *Relevance* – Include only the emissions sources and conditions that are characteristic of PHL.
- *Transparency* – Provide clear and understandable results that enable reviewers to assess the credibility and reliability of the findings.

This GHG emissions inventory was prepared based on 3 commonly used and widely accepted guidelines for assessing GHG emissions associated with the aviation sector, in general, and airports in particular:

- Transportation Research Board, Airport Cooperative Research Program (ACRP) Report 11, *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*[8];
- U.S. Environmental Protection Agency (USEPA) *Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Optional Emissions from Commuting, Business Travel and Product Transport*[9]*;* and the
- Intergovernmental Panel on Climate Change (IPCC) *Guidelines for National Greenhouse Gas Inventories*. [10]

The majority of the technical analysis was accomplished using the latest version of the Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System[11] (EDMS version 5.1.4.1) and the USEPA Motor Vehicle Emission Simulator[12] (MOVES version 2010b). Other emission factors used to compute the GHG emissions inventory were obtained from a variety of references as they are specific to the individual source type, fuel type and/or activity level.

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[8] Transportation Research Board, ACRP Report 11, *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*, 2009, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf.

[9] U.S. Environmental Protection Agency, Climate Leaders *Greenhouse Gas Inventory Protocol Core Module Guidance, Optional Emissions from Commuting, Business Travel and Product Transport*, May 2008, http://www.epa.gov/climateleadership/documents/resources/commute_travel_product.pdf.

[10] IPCC Guidelines for National Greenhouse Gas Inventories, Volume 2, 2006, www.ipcc-nggip.iges.or.jp/public/gl/invs5.htm.

[11] FAA, Emissions Dispersion Modeling System (EDMS), http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.

[12] USEPA, MOVES (Motor Vehicle Emission Simulator), http://www.epa.gov/otaq/models/moves/.

1.3 Current Emissions Reduction Efforts

Over the past several years, PHL has initiated a number of emission reduction measures through the FAA's Voluntary Airport Low Emissions (VALE) Program[13]. The VALE Program allows airport sponsors to use Airport Improvement Program (AIP) funds and Passenger Facility Charges (PFC) to finance low emission vehicles, refueling and charging stations, gate electrification, and other airport air quality improvements. The emission reduction measures implemented via the VALE program at PHL include:

Electric Belt Loaders and Charging Stations

- Purchase of hybrid vehicles.
- Installation of pre-conditioned air on 11 Terminal A East electrified jet bridges.
- Installation of pre-conditioned air on 24 electrified jet bridges within Terminal F.
- Purchase and installation of 5 charging stations for 10 electric ground support equipment (eGSE) associated with United Airlines.
- Purchase and installation of 15 charging stations for 34 eGSE associated with US Airways.
- Purchase and installation of 25 charging stations to support up to 184 eGSE.
- Purchase and installation of 5 ground power units (GPU) at the US Airways Maintenance Hangar.

Additional GHG reduction initiatives implemented at PHL include:

- Reducing the Airport's energy consumption through Energy Conservation Measures (ECMs).
- Ground transportation improvements geared to improve ground circulation, reduce air emissions, and reduce dependence on fossil fuels and single-occupancy vehicles.
- US Airways completed construction of a new ground support equipment (GSE) maintenance building - the first LEED Silver certified facility to be constructed at PHL.
- Expansion and renovation of the commuter Terminal F baggage claim building to improve passenger amenities. This building anticipates achieving LEED Silver certification.

US Airways LEED Certified GSE Building

- Implementation of the Waste Reduction Program which is a single-stream recycling program for solid waste within public terminal areas and airport offices.

[13] City of Philadelphia to Pennsylvania Department of Environmental Protection, Airport Emission Reduction Credit Statements, Philadelphia International Airport, April 7, 2011.

2 Regulatory and Policy Context

This section presents an overview of the most prominent GHG regulatory actions that have been enacted or proposed to reduce GHG emissions at a national, regional, statewide, and local level. Presently, there are no GHG-related regulations specifically directed at airports in the United States.

2.1 National

Historically, GHG emissions have not been regulated under the Federal Clean Air Act (CAA) as air pollutants. However, after the U.S. Supreme Court in 2007 clarified that CO_2 is an "air pollutant" subject to regulation under the CAA, the U.S. Environmental Protection Agency (USEPA) embarked on developing requirements and standards for GHG emissions from mobile and stationary sources under the CAA. The following summarizes the main GHG regulatory initiatives recently undertaken by the USEPA.

In 2009, USEPA issued the *Mandatory Reporting of Greenhouse Gases Rule* which requires reporting of GHG data and other relevant information from large sources and suppliers in the United States. The purpose of the rule is to collect accurate and timely GHG data to inform future policy decisions. Suppliers of certain products that would result in GHG emissions if released, combusted or oxidized; direct emitting source categories; and facilities that inject CO_2 underground for geologic sequestration or any purpose other than geologic sequestration, are covered. Facilities that emit 25,000 metric tons (MT) or more per year of GHGs are required to submit annual reports to the USEPA. For some source categories (e.g., power plants, concrete manufacturing), reporting began in 2010. For reporting year 2012, over 8,000 facilities and suppliers reported to the greenhouse gas reporting program. Importantly, PHL does not fall within these criteria.

USEPA is also responsible for developing and implementing regulations to ensure that transportation fuel sold in the United States contains a minimum volume of renewable fuel. By 2022, the *Renewable Fuel Standard (RFS) Program*, which was created under the Energy Policy Act (EPAct) of 2005, anticipates reducing GHG emissions by 138 million MT, equivalent to the annual emissions of 27 million passenger vehicles. Additionally, USEPA and the National Highway Traffic Safety Administration (NHTSA) are taking coordinated steps to enable the production of a new generation of clean vehicles, through the reduction of GHG emissions and improved fuel use.

Currently, aviation-related GHG emissions are not specifically addressed under the CAA. Nearly all aviation-related emission sources are independently regulated through equipment-specific regulations, standards and recommended practices, and operational guidelines, which are established by organizations such as USEPA, FAA, and ICAO. In fact, in June 2012, the U.S. Government submitted to the ICAO an *Aviation Greenhouse Gas Emissions Reduction Plan*[14] which identifies actions and progress toward GHG emissions reductions in areas such as: aircraft and engine technology Improvement, operational improvements, alternative fuels development and deployment, policies, standards, and measures, and scientific understanding and modeling/analysis.

At the international level, the Airports Council International (ACI) aims at promoting professional excellence in airport management and operations to provide the public with a safe, efficient and environmentally responsible air transport system. ACI spearheads the Airport Carbon Accreditation (ACA) program which is an independent, voluntary program for airports focused at measuring, managing, and reducing carbon emissions from their operations, with the ultimate goal of becoming carbon neutral.

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[14] USG, Aviation Greenhouse Gas Emissions Reduction Plan, June 2012, http://www.faa.gov/about/office_org/headquarters_offices/apl/environ_policy_guidance/policy/media/Aviation_Greenhouse_Gas_Emissions_Reduction_Plan.pdf.

2.2 Regional

Pennsylvania is an observer to the Regional Greenhouse Gas Initiative (RGGI). RGGI was established in 2005, and is a cooperative effort by 9 Northeast and Mid-Atlantic states (i.e., Connecticut, Delaware, Maine, Maryland, Massachusetts, New Hampshire, New York, Rhode Island, and Vermont) to establish the design of a regional cap-and-trade program initially covering CO_2 emissions from power plants in the region. Three Canadian provinces (i.e., Ontario, New Brunswick, and Quebec) also act as observers.

RGGI was the first mandatory cap-and-trade program in the United States. RGGI requires fossil fuel power plants over 25 megawatts (MW) in participating states to obtain an allowance for each ton of CO_2 emitted annually. Power plants within the region may comply with the cap by purchasing allowances from quarterly auctions, other generators within the region, or offset projects. RGGI administered its first auction of CO_2 emissions allowances in 2008. By 2020, the RGGI CO_2 cap is projected to contribute to a 45 percent reduction in the region's annual power-sector CO_2 emissions from 2005 levels, or between 80 and 90 million short tons (tons) of CO_2.

The Delaware Valley Regional Planning Commission (DVRPC) is the designated Metropolitan Planning Organization (MPO) for the Greater Philadelphia Region. DVRPC works to promote regional cooperation in a 9-county, bi-state region. The region includes Bucks, Chester, Delaware, Montgomery, and Philadelphia counties in Pennsylvania; and Burlington, Camden, Gloucester, and Mercer counties in New Jersey. DVRPC facilitates city, county and state representatives of this region to address key concerns such as transportation, land use, environmental protection and economic development. DVRPC conducts a regional Energy Use and Greenhouse Gas Emissions Inventory on a 5-year interval, with the most recent inventory reflecting year 2010 conditions.[15]

2.3 Statewide

Pennsylvania has developed various regulations to address GHG emissions. The following summarizes the main actions undertaken by Pennsylvania:

- *Alternative Energy Portfolio Standard (AEPS) Act of 2004* – the Act was signed on November 30, 2004, and requires all electricity suppliers in Pennsylvania to provide 18 percent of their energy from advanced energy sources within 15 years (2019-2020); specifically, 8 percent should come from Tier I sources and 10 percent from Tier II sources. Tier I includes solar, wind, low-impact hydropower, geothermal energy, fuel cells, biomass, and coal mine methane sources. Tier II includes demand-side management, distributed generation systems, large scale hydropower, waste coal, municipal solid waste (MSW), byproducts of wood-pulping and manufacturing, and integrated combined coal gasification technology. On July 19, 2007, Governor Rendell signed into law Act 35 of 2007 amending portions of the AEPS Act.
- *Energy Efficiency Standards* - Pennsylvania requires new residential and commercial buildings to meet energy efficiency standards. Residential and commercial buildings statewide are required to meet the 2009 International Energy Conservation Code (IECC) and ANSI/ASHRAE/IESNA[16] Standard 90.1-2007.[17]
- *Fuel Economy Standards* - Pennsylvania imposes automobile fuel economy standards similar to California's, which include mandates to regulate GHG emissions from new

[15] DVRPC, Regional Energy Use and Greenhouse Gas Emissions Inventory, http://www.dvrpc.org/energyclimate/inventory.htm.

[16] American National Standards Institute/American Society of Heating, Refrigerating and Air-Conditioning/Illuminating Engineering Society of North America ANSI/ASHRAE/IESNA

[17] For the residential build community, states must meet or exceed the 2009 IECC or achieve equivalent or greater energy savings. For the commercial build community, states must meet or exceed ANSI/ASHRAE/IESNA Standard 90.1-2007 or achieve equivalent or greater energy savings to qualify to receive federal funding.

vehicles. On September 19, 2006, the state's Environmental Quality Board approved the *Clean Vehicles Program* to adopt California's vehicle emissions standards.

- *GHG Reporting* – Pennsylvania is a member of the Climate Registry, a collaboration aimed at developing and managing a common GHG emissions reporting system across states, provinces, and tribes. Members released a final General Reporting Protocol in May 2008. The Climate Registry began accepting data in June 2008. Pennsylvania has no mandatory GHG reporting requirements beyond USEPA's mandatory GHG reporting rule.

Additionally, on July 9, 2008, Governor Rendell signed the *Pennsylvania Climate Change Act (Act 70).* Among a number of goals, Act 70 directed the state Department of Environmental Protection (DEP) with coordination of the Pennsylvania Climate Change Advisory Committee (CCAC) to submit an Action Plan for lowering GHG emissions to the Governor within 15 months of the effective date of Act 70 and every 3 years thereafter. The first Action Plan was submitted to the Governor and General Assembly on December 18, 2009. The plan calls for a 30 percent reduction in GHG emissions by 2020. In combination with other state and federal environmental initiatives, the recommendations outlined in the action plan could reduce emissions by more than 40 percent. The first *Pennsylvania Climate Change Action Plan Update* was submitted to Governor and General Assembly on December 31, 2013, with the next update due on October 9, 2015.[18]

2.4 Local

The City of Philadelphia is strongly committed to reducing GHG emissions. The key programs/initiatives the City has partaken since 1999 include the following:

- *Cities for Climate Protection (CCP) Campaign sponsored by the International Council for Local Environmental Initiatives (ICLEI) local Governments for Sustainability* - In 1999, the City of Philadelphia agreed to a goal to reduce its GHG emissions by 10 percent from 1990 levels by 2010.

- *U.S. Mayors' Climate Protection Agreement sponsored by the U.S. Conference of Mayors (USCM)* - In 2005, the City of Philadelphia aimed at meeting or surpassing the United States' GHG reduction targets recommended under the Kyoto Protocol (i.e., 7 percent from 1990 levels), and to urge state and federal governments to enact stronger policies and programs.

- *Large Cities Climate Leadership Group and Clinton Climate Initiative (CCI)* - In 2006, the City of Philadelphia joined an international group of major cities committed to reduce urban CO_2 emissions and adapt to climate change.

- *Local Action Plan for Climate Change* - In April 2007 the City of Philadelphia completed the Local Action Plan for Climate Change which aimed at ensuring that the broader community and the City government meet or exceed the CCP commitment to reduce GHG emissions by 10 percent by 2010 and to help Philadelphia prepare for the responsibilities and opportunities of GHG reduction and adaptation beyond 2010.

- *Philadelphia's Greenhouse Gas Inventory* - In April 2007 Philadelphia's Greenhouse Gas Inventory was completed, which looked at CO_2 emissions for Philadelphia from a community level as well as a government level. The GHG emissions inventory took 1990 as a baseline year, 1997 and 2006 as interim years for verification, and 2010 as the forecast year.

- *Greenworks Philadelphia* - Mayor Michael Nutter established the city's first Office of Sustainability and released in 2009 "Greenworks Philadelphia", the city's first comprehensive sustainability plan. The 2014 Greenworks Progress Report, is the latest report and reflects

[18] Pennsylvania DEP, Pennsylvania Climate Change Action Plan Update, December 2013, http://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/Climate%20Change%20Advisory%20Committee/Final_Climate_Change_Action_Plan_Update.pdf.

the culmination of 5 years of work toward the energy, environment, equity, economy, and engagement targets established in the initial 2009 plan.[19]

[19] Mayor's Office of Sustainability, City of Philadelphia, http://www.phila.gov/green/PDFs/Greenworksprogressreport.pdf.

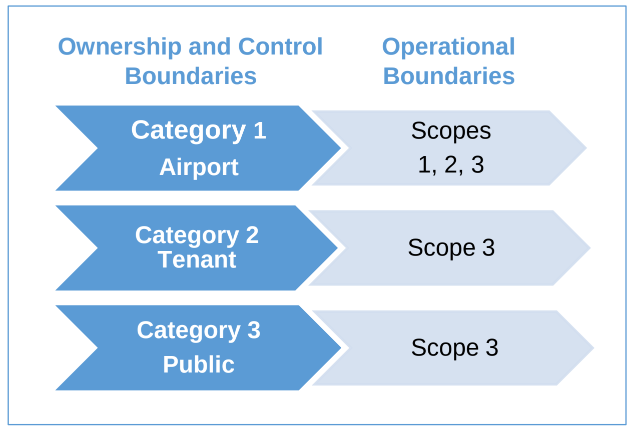
3 Boundaries and Scope

Defining boundaries and source categories aids in interpreting emissions inventory results and indicates the degree of ownership and control the airport owner may have on particular sources. The following section outlines these concepts and how they are applied to the PHL GHG emissions inventory.

3.1 Planning Category (Ownership and Control Boundaries)

ACRP Report 11 identifies 3 airport planning categories characterized by degrees of ownership and control that an airport may have, as summarized below.

- **Category 1 –** GHG emissions from sources that are owned and controlled by the reporting entity (i.e., PHL). These sources typically represent all Scope 1 and 2 sources, and only those Scope 3 sources which are not owned by the entity, but over which the entity can exert control. At PHL, these sources include airport-owned and controlled stationary sources (e.g., boilers, generators, etc.), ground access vehicles such as fleet vehicles, motor vehicles traveling on airport roadways and within parking facilities, ground support equipment, snow removal equipment, electrical consumption, and construction activities.

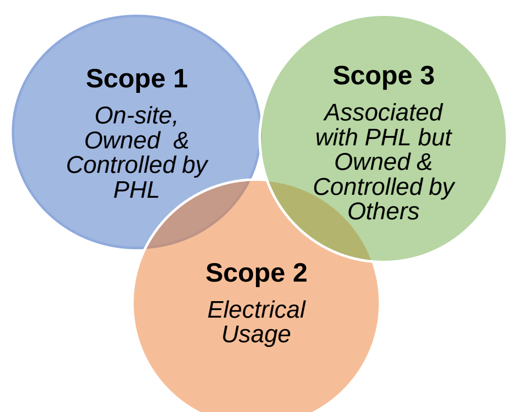


- **Category 2 –** This category comprises Scope 3 emissions associated with sources owned and controlled by airlines and airport tenants. These sources include aircraft (on-ground, within the landing-takeoff [LTO] cycle, and within cruise mode), auxiliary power unit (APU), ground support equipment, electrical consumption, ground access vehicles, and stationary sources controlled by tenants.
- **Category 3 –** This category comprises GHG emissions associated with public sources associated with the Airport and not owned/controlled by the Airport or tenants. These include public owned and controlled sources such as: passenger automobiles, taxis, limousines, buses, and shuttle vans, which are operating on the off-airport roadway network.

3.2 Scope (Operational Boundaries)

Once the ownership and control boundaries were determined, the operational boundaries (or scopes) were also set. Consistent with the guidelines of *ACRP Report 11*, operational boundaries were established as described below.

- **Scope 1 –** GHG emissions from sources that are owned and controlled by the reporting entity (i.e., PHL). These include on-airport owned and controlled stationary sources (e.g., boilers, emergency generators, etc.), fleet vehicles, and vehicles using on-airport roadways and associated areas.
- **Scope 2 –** GHG emissions associated with the generation of electricity consumed by the reporting entity and its tenants.



- **Scope 3 –** GHG emissions that are attributed to activities at PHL, but are associated with sources that are owned and controlled by others. These include aircraft-related emissions, emissions from airport tenant's activities, and public ground transportation to and from the Airport.

Table 1 provides a listing of the PHL GHG emission sources analyzed in the 2013 GHG emissions inventory by planning category and scope. Of note, GHG emissions associated with construction, refrigerants, and waste management activities were conservatively considered as Category 1 sources (under Scopes 1 and 3), as these emissions may be associated with sources/activities that are owned and controlled by the Airport as well as by other entities.

Table 1. Sources of Greenhouse Gas Emissions by Planning Category and Scope

Planning Category	Emission Source	Scope
Category 1 – Airport	Stationary Sources	1
	GSE	1
	GAV - Fleet Vehicles	1
	GAV - Employee Vehicles	1
	GAV - Parking Facilities	1
	GAV - Vehicles On-Airport Roadways	1
	Fire Training Facility	1
	Contracted Shuttles	1
	Construction	1 and 3
	Refrigerants	1 and 3
	Waste Management	1 and 3
	Electrical Usage	2
Category 2 – Tenant	Aircraft	3
	Aircraft Engine Startup	3
	APU	3
	GSE	3
	GAV - Fleet Vehicles	3
	GAV - Employee Vehicles	3
	GAV - Parking Facilities	3
	GAV - Vehicles Off-Airport Roadways	3
	Electrical Usage	2
	Contracted Shuttles	3
Category 3 – Public	GAV - Vehicles Off-Airport Roadways	3
	SEPTA Public Transit	3

Notes: **APU** – Auxiliary Power Unit, **GAV** – Ground Access Vehicles, **GSE** – Ground Support Equipment, and **SEPTA** – Southeastern Pennsylvania Transportation Authority.

4 Sources of GHG Emissions

4.1 Types of GHG Emissions

According to the IPCC, there are 6 types of GHGs: carbon dioxide (CO_2), methane (CH_4), and nitrous oxide (N_2O), and the fluorinated gases hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). Due to the fact that CO_2, CH_4, and N_2O are by-products of fuel combustion, they are also the predominant GHGs at airports. These gases arise from the combustion of fossil fuels such as jet fuel, aviation gasoline (Avgas), gasoline, and diesel and are emitted as by-products contained in the engine exhausts. Emissions of HFCs, PFCs, and SF_6 occur at airports, but to a far lesser extent, and are typically related to refrigeration, air conditioning, and other coolants. **Table 2** presents the characteristics of these GHGs.

Table 2. Types of Greenhouse Gases

Pollutant	Characteristics
Carbon Dioxide (CO_2)	CO_2 enters the atmosphere through the burning of fossil fuels such as coal, natural gas and oil; solid waste; trees and wood products; as well as certain chemical reactions. CO_2 is removed from the atmosphere when it is absorbed by plants as part of the biological carbon cycle.
Nitrous Oxide (N_2O)	N_2O is emitted during agricultural and industrial activities, as well as during combustion of fossil fuels and solid waste.
Methane (CH_4)	CH_4 is emitted during the production and transport of coal, natural gas, and oil. In addition, CH_4 emissions result from livestock and other agricultural practices, and by the decay of organic waste in municipal solid waste landfills.
Fluorinated Gases	HFCs, PFCs and SF_6 are synthetic GHGs that are emitted from a variety of industrial processes. These gases are typically emitted in smaller quantities, but due to their potency, they are sometimes referred to as high Global Warming Potential (GWP) gases.

Source: USEPA, Overview of Greenhouse Gases, 2014. http://www.epa.gov/climatechange/ghgemissions/gases.html.

4.2 Sources of GHG Emissions

The primary sources of GHG emissions at PHL include aircraft; ground access vehicles (GAVs) such as vehicles operating on-airport roadways, parking facilities and terminal curbsides, and off-airport roadways; GSEs and APUs; construction vehicles and equipment; and an assortment of stationary sources. Emissions from these sources arise primarily from the combustion of fossil fuels (i.e., jet fuel, Avgas, diesel, gasoline, compressed natural gas, etc.) and are emitted as by-products contained in the engine exhaust. Additional sources such as electricity consumed by PHL and its tenants (but generated elsewhere by the burning of coal, oil, and natural gas) as well as refrigerants used in vehicles, refrigeration, heating and air-conditioning systems and waste management practices were also included as sources.

It is important to note that GHG emissions associated with the “supply chains” or “life cycles” (e.g., production, consumption and/or disposal of goods and materials such as paper, plastic and waste products, foodstuffs, and building materials) by either airport facilities or tenant facilities are not included in this analysis. **Table 3** summarizes the sources of GHG emissions at PHL.

Table 3. Sources of Greenhouse Gases

Source Category	Characteristics
Aircraft	Exhaust products of fuel combustion that vary depending on aircraft engine type (i.e., turbo-jet, turbo-prop, etc.), fuel type (Jet-A, avgas), number of engines, power setting (i.e., taxi/idle, take-off, cruise), and amount of fuel burned.
Ground Access Vehicles	Exhaust products of fuel combustion from passenger and airport/tenant employee vehicles using airport parking facilities and on- and off-airport roadways. These include motor vehicles, taxis, limousine, vans, rental cars, buses, shuttles as well as airport owned vehicles. Emissions vary depending on vehicle type (i.e., gasoline, diesel, etc.) and the amount of fuel consumed.
Ground Support Equipment/Auxiliary Power Units	Exhaust products of fuel combustion from equipment used by airport operators (e.g., snow removal, maintenance equipment, etc.) and tenants (e.g., aircraft service trucks, aircraft tractors, tow tugs, belt loaders and other portable equipment). Emissions are also emitted by auxiliary power units used to furnish power to aircraft when main engines are off.
Stationary Sources	Exhaust products of fossil fuel combustion from boilers, emergency generators, and space heating.
Electrical Usage	Emissions associated with the production of electricity at off-site utilities that use coal, oil, or natural gas.
Construction	Exhaust products of fuel combustion associated with construction equipment (e.g., excavators, forklifts, etc.) and vehicles (e.g., dump trucks, water trucks, etc.) during construction activities.
Refrigerants	A range of chemicals used for refrigeration, air conditioning, and other coolants that are comprised of substances possessing global warming characteristics (e.g., Freon, chlorofluorocarbons, etc.).
Waste Management	Emissions associated with the solid waste generated at the Airport; and, the reduction in emissions associated with recycling and solid waste disposal practices employed by the Airport.

Source: KBE, 2015.

5 GHG Calculation Methodology

The information, data and recommendations contained in this report were developed in accordance with procedures and practices that are current and considered appropriate for this application. As discussed above, the GHG emissions inventory was conducted following 3 commonly used and industry-wide accepted guidelines for assessing GHG emissions: ACRP, IPCC, and USEPA. This section details the sources of data for the GHG inventory and the inputs and assumptions to the models used for the inventory.

5.1 Data Collection

The information and data collected for the preparation of the PHL GHG emissions inventory came from a variety of sources and were considered to be the most up-to-date and appropriate for this application. To the extent data were available, this information reflects actual conditions at PHL such as: aircraft activity levels, GSE fleet characteristics, motor vehicle traffic volumes, fuel utilization throughput, and electrical usage. For those instances where data was not readily available, reasonable assumptions and engineering judgment were applied. **Table 4** presents the sources of data and information used in the PHL GHG emissions inventory.

Table 4. Sources of Data and Information

Source Category	Sources of Data and Information
Aircraft	▪ *Total operations and fleet mix* – PHL Airport Noise and Operations Monitoring System and FAA Tower Counts, 2013 Aviation Activity Report ▪ *Time-in-Mode* – Bureau of Transportation Statistics ▪ *Emission factors* – EDMS5.1.4.1 and USEPA GHG Emissions Factors Hub ▪ *Jet A/AvGas Fuel Usage* – PHL 2013 Fuel Usage Data
Ground Access Vehicles	▪ *Fleet Vehicles' Fuel Usage* - City Government GHG Inventory 2013 ▪ *Employee Vehicles VMT* – Derived from Active Badge Report with zip codes ▪ *Total Number of Employees* – PHL Active badge Report ▪ *On- and off-airport VMT (passenger vehicles, taxis, shuttles, etc.)* – Terminal Approaches Class Counts and 2013 RAC Shuttle Fleet Data ▪ *Parking Facilities* – 2013 Aviation Annual Disclosure Report ▪ *Public Transit* – SEPTA 2013 Route Statistics ▪ *Emission Factors* – MOVES2010b and USEPA GHG Emissions Factors Hub
Ground Support Equipment/Auxiliary Power Units	▪ *Emission factors* – EDMS5.1.4.1 and USEPA GHG Emissions Factors Hub ▪ *GSE types and operating times* – EDMS5.1.4.1 Defaults ▪ *GSE Gasoline/Diesel Usage* - PHL 2013 Fuel Usage Data and 2013 Snow Billing Data ▪ *APU types and operating times* – PHL Jetbridge Survey and Inventory ▪ *Engine and fuel types* – EDMS5.1.4.1 Defaults
Stationary Sources	▪ *Source and fuel types and throughput volumes* – City Government GHG Inventory 2013, Pennsylvania Department of Environmental Protection 2013 Emission Inventory Production Report ▪ *Emission factors* – USEPA Climate Leadership
Electrical Usage	▪ *Electrical usage* – City Government GHG Inventory 2013 and PHL Square Footage ▪ *Emission factors* – USEPA Year 2010 eGRID 9th edition Version 1.0 February 2014
Construction	▪ *Airport Construction Emission Inventory Tool* (ACEIT) Version 1.0
Refrigerants	▪ *Refrigerant usage* – PHL Email dated September 11, 2014 ▪ *Emission factors* – USEPA GHG Emissions Factors Hub
Waste Management	▪ *Solid waste and recycling tonnage* – PHL 2013 Annual Recycling Report, dated June 2014 ▪ *Emission factors* – USEPA Waste Reduction Model (WARM Version 13, dated June 2014)

5.2 Pertinent Inputs, Assumptions, and Emission Factors

The pertinent input data, assumptions, and emission factors used to prepare the 2013 PHL GHG emissions inventory are summarized in **Table 5**. Details on the specific sources and data used in the GHG analysis are further described in **Appendix C**.

Table 5. Pertinent Inputs, Assumptions, and Emission Factors

Source Category	Source	Description	Ownership	Assumptions	Input Data	Emission Factors
Aircraft	Aircraft Ground Taxi	Includes taxi-in, taxi-out and ground-based delay emissions.	Tenant	Data consisted of most up-to-date operational data and other information specific to PHL. ANOMS, EDMS default fuel flow rates, AGL time-in-mode, and airline specific ground travel time.	Aircraft Activity Levels (arrival and departures), Aircraft Type, Engine Type, and Fuel Type, times-in-mode data	USEPA[1]/EDMS[2]
	Aircraft Above Ground Level (AGL)	Ground to 3,000 feet which includes takeoff, climbout, and approach emissions up to a height of 3,000 feet.	Tenant			USEPA[1]/EDMS[2]
	Aircraft Cruise Mode	Includes emissions above 3,000 feet from airport to destination.	Tenant			USEPA[1]/EDMS[2]
	Aircraft Engine Startup	Engine startup mode occurs within the terminal gate area prior to the aircraft departure.	Tenant			USEPA[1]/EDMS[2]
	Aircraft APU	Consist of small turbine engines used by many commercial aircraft to start the main engine(s), provide electrical power, and to power the onboard HVAC systems.	Tenant	EDMS default fuel flow rates and APU assignment.		USEPA[1]/EDMS[2]
Ground Access Vehicles	Fleet Vehicles	Includes airport-owned vehicles traveling within the Airport boundaries.	Airport/Tenant	Data consistent with City Government GHG Emissions Inventory.	Fuel Usage	MOVES[3]
	Employee Vehicles	Includes airport/tenant employee vehicles travelling on- and off-airport roadways.	Airport/Tenant	Derived one-way trip distance of 20 miles for tenants and 14 miles for Airport employees from zip code data.	Number of Employees/VMT	MOVES[3]
	Parking Facilities	Includes airport/tenant employee and passenger vehicles using airport parking facilities.	Airport/Tenant	Assumed a 0.25 miles round trip distance.	Vehicle ticket counts	MOVES[3]
	Vehicles - On-Airport Roadways	Includes passenger autos, taxis, limousine, rental car shuttles, parking courtesy shuttles, hotel shuttles, van services, charter buses, rental cars travelling on-airport roadways.	Airport	Assumed vehicle travel 3 miles within the Airport boundaries.	VMT/Fuel Usage	MOVES[3]
	Vehicles - Off-Airport Roadways	Includes passenger autos, taxis, limousine, hotel shuttles, van services, charter buses, and rental cars, and other miscellaneous vehicles traveling on off-airport roadways.	Tenant/Public	Assumed travel distance for specific type of vehicle such as 44 miles for passenger trips and	Traffic volume and VMT	MOVES[3]

Source Category	Source	Description	Ownership	Assumptions	Input Data	Emission Factors
				17 miles for limos.		
Ground Access Vehicles	Contracted Shuttle Buses	Includes shuttles that provide airport/tenant employee and passenger transportation to and from airport parking lots.	Airport/Tenant	Assumed these buses to include First Transit and COBUS 3000 at PHL.	Fuel Usage	EPA[1]
	SEPTA – Public Transit	SEPTA public transit servicing the Airport (i.e., Commuter Rail and Bus Lines).	Public	Distance from farthest station/stop servicing the Airport.	Ridership/VMT	EPA[1]
Ground Support Equipment	Tenant-operated equipment	Includes baggage tugs, belt loaders, aircraft tugs, cargo lifts, lavatory service trucks, water trucks, ground power units, air start units, general service trucks etc. operated along the airside.	Tenant	Fuel usage for ASIG supported airlines and EDMS default GSE assignments and fuel usage for non-ASIG supported airlines.	GSE Type, Fuel Type, Fuel Usage, Operating Times	EPA[1]/EDMS[2]
	Snow Removal	Equipment used to remove snow to keep airside and landside areas clear and operational.	Airport	Hours of operations during 2013/2014 winter season. Fuel rates for specific equipment per NONROAD.	Fuel Usage	EPA[1]
Stationary Sources	Boilers/Heaters[4]	Stationary sources that help provide service, comfort, and/or security to passengers within airport limits.	Airport	Data consistent with City Government GHG Emissions Inventory.	Fuel Usage	EPA[1]
	Generators	Emergency generators are available to provide back-up power in the event of a blackout at the Airport.	Airport	Data consistent with PHL's 2013 Emission Inventory Production Report submitted to Pennsylvania DEP.	Fuel Usage	EPA[1]
	Fire Training Facility	Emergency response staff must train regularly to be ready for any emergency that may arise at the Airport. As part of staff training, propane fires are purposely set and extinguished.	Airport	Propane usage in 2013 by ARFF services.	Fuel Usage	EPA[1]
Construction		Construction activities result from the operation of heavy equipment in the process of grading, paving, materials handling and transportation,	Airport	Runway 27R High Speed Exit Taxiway was the construction project	Construction Activities/	ACEIT[5]

Source Category	Source	Description	Ownership	Assumptions	Input Data	Emission Factors
		and other related activities.		included in analysis.		
Electrical Usage		Electrical power is used throughout the Airport for heating, cooling, lighting, and electric services such as escalators, elevators, etc.	Airport/Tenant	Airport and tenant usage based on square footage.	Electrical usage in kilowatts	EPA[6]
Refrigerants		A range of chemicals used in refrigeration and HVAC systems that are comprised of substances possessing global warming characteristics.	Airport	Included R11 in Chillers No. 3 and 4.	Pounds of refrigerant	EPA[7]
Waste Management[9]		Waste management activities associated with airport/tenant employee and passenger activities within the Airport.	Airport	Consistent with data reported in PHL 2013 Annual Recycling Report.	Waste tonnage	WARM[8]

Notes: **ANOMS** - Airport Noise and Operations Monitoring System, **ARFF** - aircraft rescue and firefighting services, **DEP** - Department of Environmental Protection, **HVAC** - heating, ventilation, and air conditioning, **SEPTA** - Southeastern Pennsylvania Transportation Authority, **VMT** – Vehicle-Mile-Travelled.

1. USEPA, GHG Emissions Factors Hub (April 2014), www.epa.gov/climateleadership/inventory/ghg-emissions.html.
2. FAA, Emissions and Dispersion Modeling System (EDMS), http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.
3. USEPA, MOVES2010b, http://www.epa.gov/oms/models/moves.
4. This source category also includes door heaters, roof heaters, air handlers, etc. For a detailed list of sources see PHL's Synthetic Minor Operating Permit No. S12-041.
5. TRB, ACRP Report 102, http://www.trb.org/ACRP/Blurbs/170234.aspx.
6. USEPA, Emissions & Generation Resource Integrated Database (eGRID) 9th edition Version 1.0, February 2014, http://www.epa.gov/climateleadership/documents/emission-factors.pdf.
7. USEPA, Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment, May 2008 [EPA-430-K-03-004b], http://www.epa.gov/climateleadership/documents/resources/mfgrfg.pdf.
8. USEPA, Waste Reduction Model (WARM) Version 12, Updated June 2013, http://epa.gov/epawaste/conserve/tools/warm/index.html.
9. Recycling quantities are not inclusive of all tenants at PHL.

6 Results

6.1 Overview of Results

An overview of the 2013 GHG emission inventory results for PHL is reported in this section. Consistent with IPCC guidelines, the results are reported in units of MT of CO_{2e} by source and on an annual basis. **Table 6** summarizes the results by airport planning categories (i.e., airport, tenant, and public).

Table 6. GHG Emissions by Airport Planning Category

Planning Category	Emission Source	MT CO_{2e}
Category 1 – Airport	Electrical Usage	40,440
	GAV[1]	35,752
	Stationary Sources	18,474
	Contracted Shuttles	1,780
	Construction	1,282
	GSE[2]	1,046
	Refrigerants	147
	Fire Training Facility	112
	Subtotal	**99,033 (2%)**
Category 2 – Tenant	Aircraft[3]	3,885,320
	GAV[5]	162,687
	Electrical Usage	36,030
	GSE[4]	16,339
	APU	9,366
	Aircraft Engine Startup	2,546
	Contracted Shuttles	2,371
	Subtotal	**4,114,659 (92%)**
Category 3 – Public	GAV[6]	229,555
	SEPTA Public Transit[7]	31,779
	Subtotal	**261,335 (6%)**
	Total[8]	**4,475,027 (100%)**

Notes: **APU** – Auxiliary Power Unit, **GAV** – Ground Access Vehicles, **GSE** – Ground Support Equipment, and **SEPTA** – Southeastern Pennsylvania Transportation Authority.

1. GAV include airport fleet vehicles and employee traveling within parking facilities and on-airport roadways.
2. GSE includes only airport snow removal equipment.
3. Aircraft includes taxi, above the ground to 3,000 feet and cruise mode to destination.
4. GAV include tenant fleet vehicles and employee vehicles traveling within parking facilities and on both on- and off-airport roadways.
5. GSE includes tenant operated equipment such as belt loaders, baggage tractors, etc.
6. GAV include passenger vehicles traveling off-airport roadways.
7. SEPTA public transit includes those commuter rail and bus routes servicing the airport.
8. Values may reflect rounding.

For ease of comparison, the results are also presented graphically by each planning category in **Figures 1 through 3. Figure 1** presents the emissions within Category 1 which represent the emissions owned and controlled by the Airport. As shown, electricity consumption (41 percent), ground access vehicles (36 percent), and stationary sources (19 percent) represent the largest sources of GHG emissions within this category (GHG emissions related to waste management practices at PHL were estimated as part of the analysis; however, they were not included in **Figure 1** as they represent an emissions reduction and would not have been properly represented in the chart).

Figure 1. Category 1 - Airport GHG Emissions

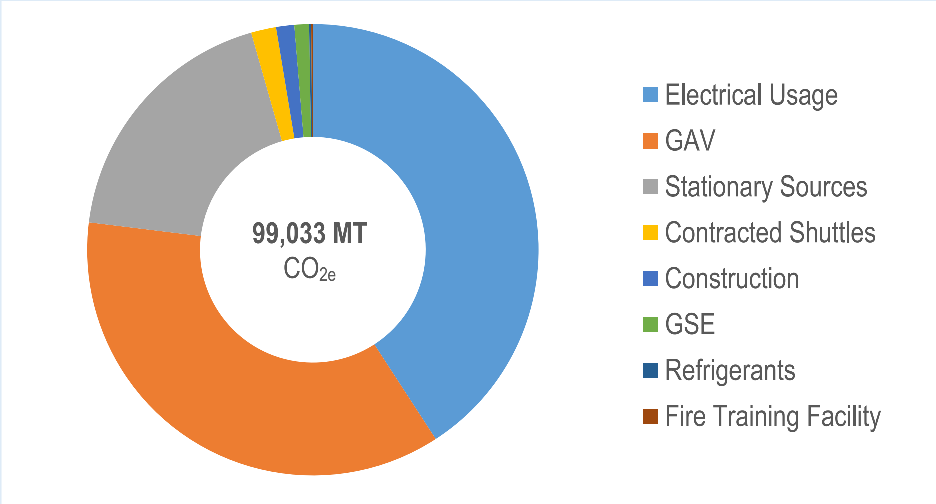


Figure 2 presents the emissions within Category 2 which represent the emissions owned and controlled by Airport tenants. As shown, aircraft comprise the majority of the GHG emissions amounting to 94 percent of the category followed by ground access vehicles travelling on off-airport roadways at 4 percent and electrical usage at 1 percent.

Figure 2. Category 2 - Tenant GHG Emissions

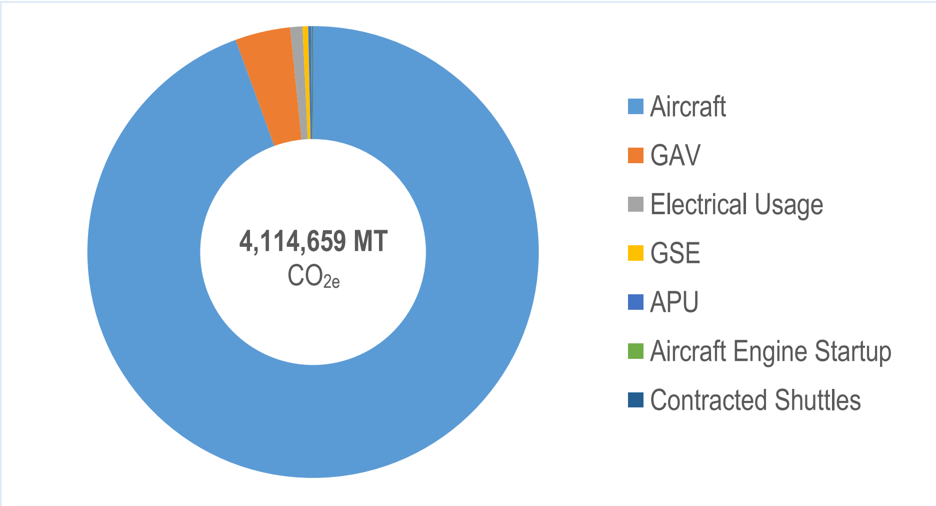


Figure 3 presents the emissions within Category 3 which comprises GHG emissions attributable to public sources associated with the Airport and not owned/controlled by the Airport or tenants. As shown, ground access passenger vehicles travelling on off-airport roadways comprise the majority of the GHG emissions amounting to 88 percent of the category followed by public transit at 12 percent.

Figure 3. Category 3 - Public GHG Emissions

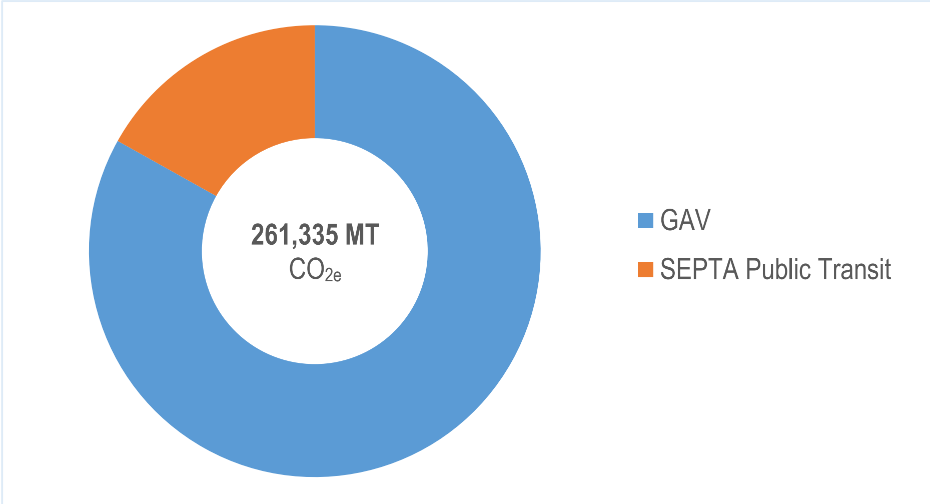


Table 7 presents the GHG emissions by scope and their respective emission sources. As shown, the majority of the GHG emissions are classifiable as Scope 3, and are primarily associated with aircraft activities – sources that are not owned and controlled by PHL.

Table 7. GHG Emissions by Scope

Scope	Ownership	Emission Sources	MT CO_{2e}
1	**Airport**	GAV[1]	35,752
		Stationary Sources	18,474
		Contracted Shuttles	1,780
		Construction	1,282
		GSE[2]	1,046
		Refrigerants	147
		Fire Training Facility	112
		Subtotal	**58,593 (1%)**
2	**Airport/ Tenant**	Airport Electrical Usage	40,440
		Tenant Electrical Usage	36,030
		Subtotal	**76,469 (2%)**
3	**Tenant/Public**	Aircraft[3]	3,885,320
		GAV[4]	392,242
		SEPTA – Public Transit[5]	31,779
		GSE[6]	16,339
		APU	9,366
		Aircraft Engine Startup	2,546
		Contracted Shuttles	2,371
		Subtotal	**4,339,964 (97%)**
		Total[7]	**4,475,027 (100%)**

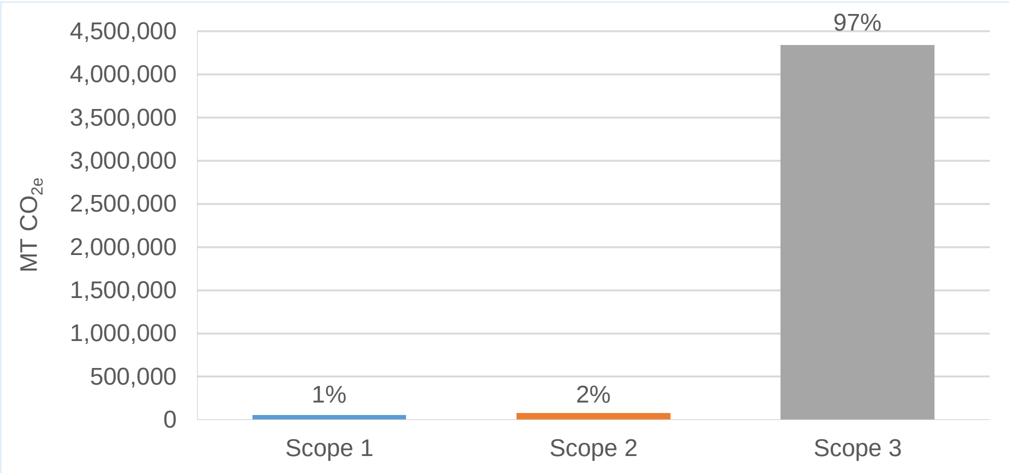
Notes: **APU** – Auxiliary Power Unit, **GAV** – Ground Access Vehicles, **GSE** – Ground Support Equipment, and **SEPTA** – Southeastern Pennsylvania Transportation Authority.

1. GAV include airport fleet vehicles and employee vehicles traveling within parking facilities and on-airport roadways.
2. GSE includes only airport snow removal equipment.
3. Aircraft includes taxi, above the ground to 3,000 feet and cruise mode to destination.

4. GAV include tenant fleet vehicles and employee vehicles traveling within parking facilities and on both on- and off-airport roadways.
5. SEPTA public transit includes those commuter rail and bus routes servicing the airport.
6. GSE includes tenant operated equipment such as belt loaders, baggage tractors, etc.
7. Values may reflect rounding.

Figure 4 presents the GHG emissions by scope in terms of percentages. As shown, the majority of the GHG emissions are classifiable as Scope 3 (97 percent), followed by Scope 2 (2 percent), and Scope 1 (1 percent). Notably, the Airport only owns and controls Scope 1 sources, but exerts control over the demand for Scope 2 sources (i.e., electrical usage).

Figure 4. GHG Emissions by Scope



6.2 Detailed Results

This section presents the detailed results of all the sources included in the PHL GHG emissions inventory, as shown in **Table 8**. The sources were grouped within six categories: aircraft, GAV, GSE, stationary sources, electrical usage, and other sources (construction activities, refrigerants, and waste management).

Table 8. GHG Emissions by Source

Source		MT CO_{2e}
Aircraft		
	Aircraft - Ground Taxi	228,208
	Aircraft – Above the Ground to 3,000 feet	172,233
	Aircraft – Cruise Mode to Destination	3,484,880
	Aircraft Engine Startup	2,546
	Auxiliary Power Units (APU)	9,366
Ground Access Vehicles (GAV)		
Fleet Vehicles	Airport Fleet Vehicles	1,156
	Tenant Fleet Vehicles	464
Employee Vehicles	Airport Employee Vehicles	3,038
	Tenant Employee Vehicles	78,543
Vehicles Parking Facilities	Airport Parking Facilities (i.e., employee lot)	82
	Tenant Parking Facilities (i.e., economy, garage parking and short-term)	493

Source		MT CO_{2e}
Off-Airport Roadways	Passenger Autos	229,555
	Taxis	4,400
	Limos/ Sedan Service	1,182
	SEPTA Rail off-site	26,919
	SEPTA Bus	4,861
	Hotel Shuttle	1,012
	Van Service	3,083
	Charter Bus	1,003
	Rental Cars	72,508
On-Airport Roadways	Passenger Autos	15,651
	Taxis	2,640
	Limos/ Sedan Service	209
	Rental Car Shuttles	4,147
	Parking Courtesy Shuttle	5,190
	Hotel Shuttle	607
	Van Service	402
	Charter Bus	68
	Small Service Truck	1,053
	Others	216
	Rental Cars	1,293
Contracted Shuttles	First Transit Contracted Shuttles Economy/ Employee Lots (employees)	2,371
	First Transit Contracted Shuttles Economy/ Employee Lots (passengers)	1,186
	COBUS 3000 leased by US Airways (on-airport passenger shuttles)	594
Ground Support Equipment (GSE)		
	Airport GSE (i.e., Snow Removal Equipment)	1,046
	Tenant GSE (i.e., aircraft tractors, baggage tractors, belt loaders, etc.)	16,339
Stationary		
	Generators	85
	Boilers/Space Heaters	18,389
	Fire Training Facility	112
Electrical Usage		
	Airport Electrical Usage	40,440
	Tenant Electrical Usage	36,030
Other Sources		
	Construction	1,282
	Refrigerant	147
	Waste Management	- 5,820
	Total[1]	**4,475,027**

Note 1: Values may reflect rounding. Total does not include waste management GHG emissions reduction.

The GHG emissions related to waste management practices at PHL were also estimated as part of the GHG emissions inventory as they represent a portion of PHL's emissions reduction initiatives. The negative results shown in **Table 8** represent the difference in emissions between a scenario which assumes all waste is landfilled with no methane treatment, and PHL's actual waste management conditions in which portions of waste are recycled and portions are landfilled requiring methane treatment. The GHG emission reductions due to recycling and landfill avoidance is approximately 5,820 MT of CO_{2e}, a large portion of which was associated with single-stream recycling management practices.[20]

6.3 Comparison to 2006 GHG Emissions Inventory

A GHG emissions inventory was previously conducted for PHL in 2009 using a baseline year of 2006. **Table 9** and **Figure 5** present a comparison of the 2006 GHG emissions to the 2013 inventory, delineated by planning category. As shown, the total GHG emissions in 2006 were estimated[21] to be 4,586,873 MT of CO_{2e}, compared to the 2013 emission inventory results at 4,475,027 MT of CO_{2e}. This amounts to a reduction of approximately two percent overall, which is due in part to the Airport's emissions reduction initiatives as well as a decrease in passenger activity and aircraft operations over this timeframe. The difference in emissions is also due to slight differences in methodology, assumptions, and available data between the two analysis years.

In summary, GHG emissions associated with the Airport and public sources decreased from 2006 to 2013. By comparison tenant-related GHG emissions increased even though aircraft emissions decreased, this was offset by an increase in GAV emissions due to a more accurate accounting of GAV.

Table 9. Comparison of 2006 and 2013 GHG Emissions Inventory

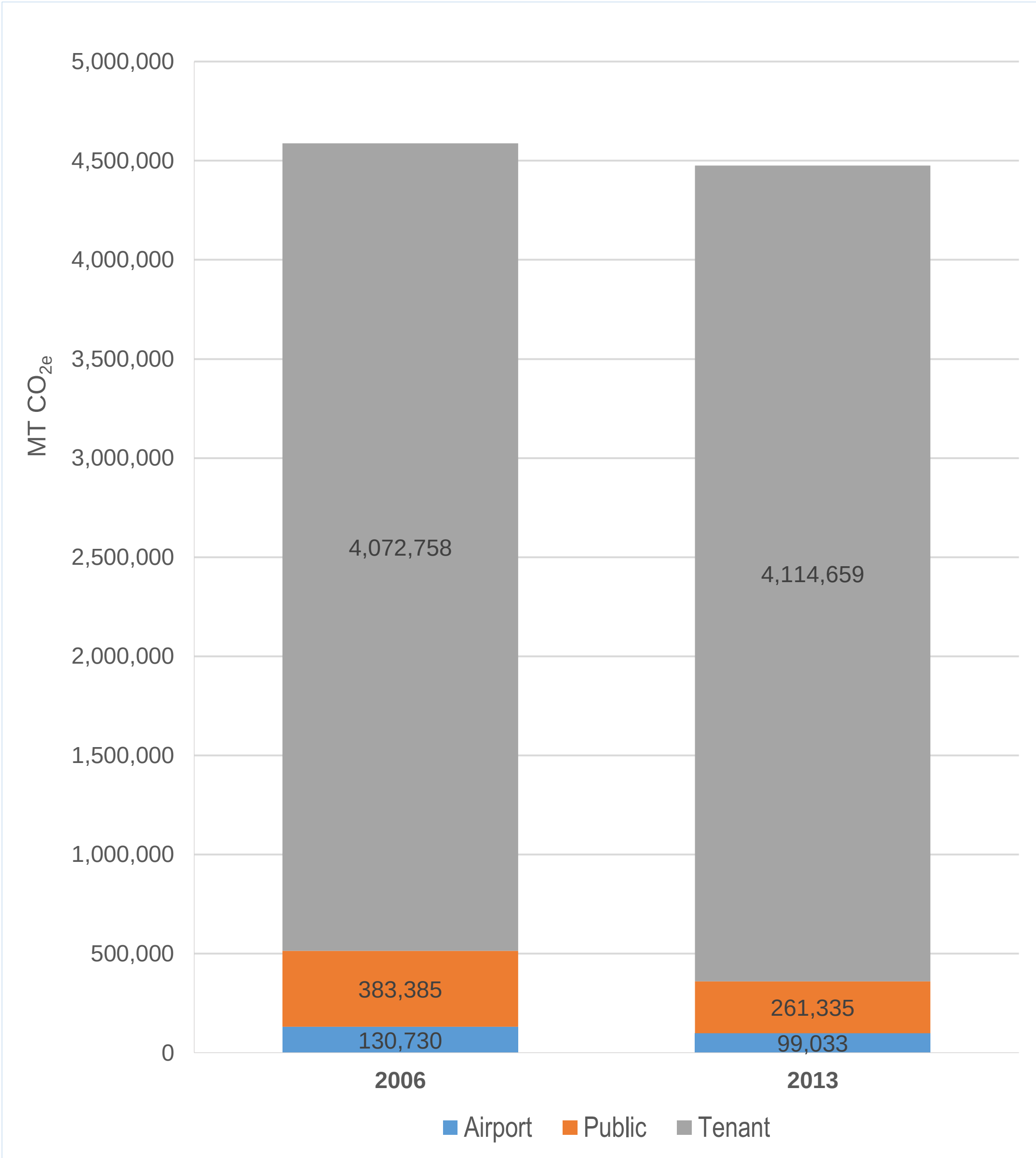
Planning Category	2006 (MT CO_{2e})	2013 (MT CO_{2e})	Difference (MT CO_{2e})	Percent Difference (%)
Airport	130,730	99,033	- 31,697	- 24
Public	383,385	261,335	- 122,050	- 32
Tenant	4,072,758	4,114,659	+ 41,901	+ 1
Total[1]	**4,586,873**	**4,475,027**	**- 111,846**	**- 2**

Note 1: Totals may reflect rounding.

[20] Emissions estimates based on data available from the City of Philadelphia's Division of Aviation (DOA), US Airways, and Marketplace Philadelphia. Recycling quantities are not inclusive of all tenants at PHL.

[21] An error was found in the 2006 emissions inventory. The CH_4 emissions for Airport stationary sources were reported as 3,122 metric tons; this was the amount in pounds. Thus, the corrected total emissions for Airport owned was 130,730 metric tons and the grand total was 4,586,873 metric tons as shown in this section.

Figure 5. Comparison of 2006 and 2013 GHG Emissions Inventory



7 Emissions Reduction Initiatives

7.1 Past and Present Initiatives

One strategy for reducing airport GHG emissions is to focus on airport owned and controlled sources and adopt measures which can reduce these emissions. PHL has adopted and continues to maintain many successful GHG reduction initiatives. They are classified as shown below.

Waste Management:

- Organic Waste Pilot Program to coordinate recycling efforts with tenants, expand recycling efforts to include landside recyclables, and to explore materials that can reduce PHL's overall waste stream.
- Waste Reduction Program, a single-stream recycling program for solid waste within public terminal areas and airport offices.

Vehicles and Transportation:

- Purchase of hybrid vehicles.
- Replacement of 11 diesel buses with 9 COBUS high-efficiency shuttle buses for US Airways shuttle operations on airfield between terminals.
- Use of B5 biodiesel in all City of Philadelphia owned and operated equipment.
- Discount on the Southeastern Pennsylvania Transportation Authority (SEPTA) monthly transit passes for Airport employees.
- Installation of bicycle parking facilities for passengers and employees.
- Authorization of a compressed work schedule in summer months for the City of Philadelphia's Division of Aviation (DOA) employees.
- Use of all hybrid vehicles for the Freedom Taxi Company.
- Use of Zenith electric vans for Renaissance Hotel.
- Installation of a compressed natural gas (CNG) station at WallyPark (Off-Airport Parking) and purchase of CNG shuttle fleet.
- Ground transportation improvements geared to improve ground circulation, reduce air emissions, and reduce dependence on fossil fuels and single-occupancy vehicles.

Facilities:

- Installation of pre-conditioned air and 400 Hz power at over 90 percent of aircraft gates (e.g., 11 electrified jet bridges within Terminal A East and 24 electrified jet bridges within Terminal F).
- Installation of interior and exterior LED lighting, including airfield lighting.
- Upgrade of boilers and other equipment in Central Utilities Building.
- Installation of variable speed drives on cooling towers.
- Construction of all new/renovated buildings over 10,000 square feet to meet LEED Silver standard.
    - US Airways completed construction of a new GSE maintenance hangar which is the first LEED Silver certified facility to be constructed at PHL.

- Commuter Terminal F baggage claim building anticipates achieving LEED Silver certification.

- Installation of porous paving at ExpressPark (Off-Airport Parking) and LED lighting at parking facility.

Airside:

- Purchase of 141 electric GSE and installation of over 200 charging stations associated with United Airlines and US Airways.
- Acquisition of 5 GPUs for use at US Airways maintenance hangar.

Planning:

- Completion of the Climate Adaptation Plan in 2010.
- Completion of a Bicycle Access Plan in 2013.
- Reducing the Airport's energy consumption through ECMs.

7.2 Potential Future Initiatives

Table 10 summarizes a series of potential GHG emissions reduction measures to be considered by PHL. For evaluation purposes, an indication of the estimated emissions reduction potential and associated costs are also identified for each measure.

Table 10. Potential Initiatives and Related Emissions Reductions and Costs

Initiative	Potential for Emissions Reduction (Low/Med/High)	Estimated Cost Ranking (Low/Med/High)
Waste Management		
▪ Expand recycling program to include food waste and additional construction and debris (C&D) materials	Low	Medium
Vehicles and Transportation		
▪ Provide incentives for alternative fuel vehicles (AFVs) using Automatic Vehicle Identification (AVI) system on commercial roadway	Low	Low
▪ Provide priority vehicle parking for emissions friendly vehicles	Low	Low
▪ Decrease headways from 30 to 20 minutes on SEPTA Airport regional rail line	Medium	High
▪ Convert the City of Philadelphia's Division of Aviation fleet vehicles to Alternative Fuel Vehicles	Medium	Medium
Facilities		
▪ Install Building Automation Systems	Medium	Medium/High
▪ Use refrigerants that meet LEED standards (lower GWP/CFC free)	Low	Medium/High
▪ Replace windows and doors to improve building envelopes	Medium/High	Medium/High
▪ Upgrade mechanical rooms and heating, ventilation and air conditioning (HVAC) systems	Medium/High	Medium/High
▪ Construct an Automated People Mover and consolidated Ground Transportation Center (as part of the Capacity Enhancement Program)	High	High
▪ Install vegetated roofs for greater building insulation, energy savings, stormwater management	Medium	Medium
▪ Require and track low emissions construction equipment	Medium	Medium

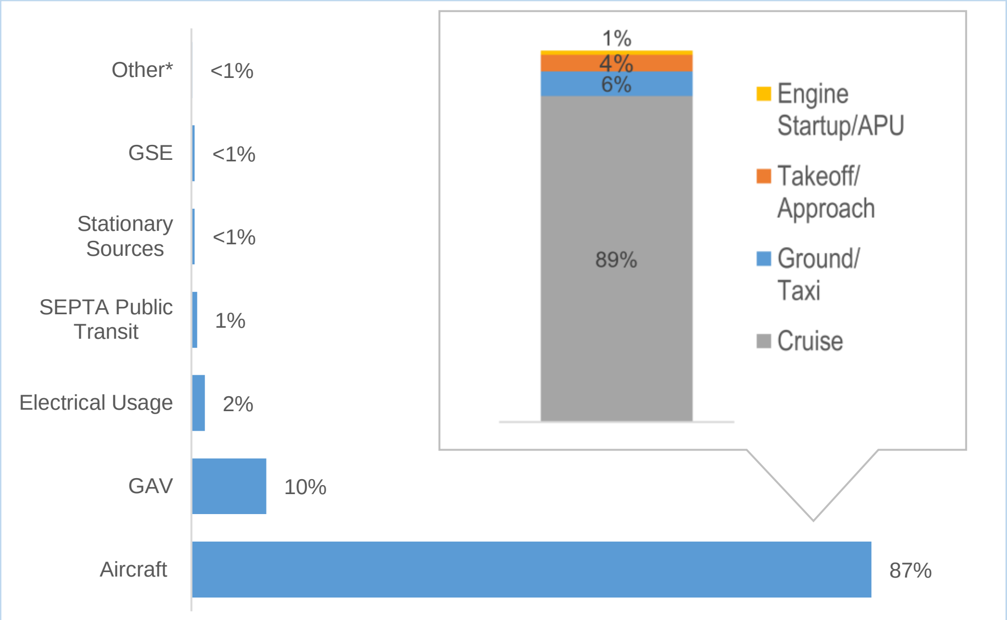
Initiative	Potential for Emissions Reduction (Low/Med/High)	Estimated Cost Ranking (Low/Med/High)
Airside		
▪ Encourage airlines to use single-engine taxi procedures	Medium	Low
Planning		
▪ Establish a Sustainability Committee and prepare Sustainability Plan	Low	Low
▪ Participate in a GHG registry and/or Airport Council International's Airport Carbon Accreditation program	Low	Low

8 Conclusion

This GHG emissions inventory was completed for PHL for the year 2013. The main objective of the inventory was to assist PHL with identifying, quantifying, and managing the Airport's emissions of GHGs in accordance with its commitment to environmental stewardship.

Overall, the majority of the GHG emissions were attributed to aircraft operations, which amounted to 87 percent of the total. Of note, approximately 89 percent of these aircraft emissions occurred at cruise mode, representing a segment of the aircraft flight beyond the local environs of PHL. Ground access vehicles were the second-highest emitting sources in the inventory, representing 10 percent of GHG emissions. **Figure 6** illustrates the contributors of GHG emissions at PHL.

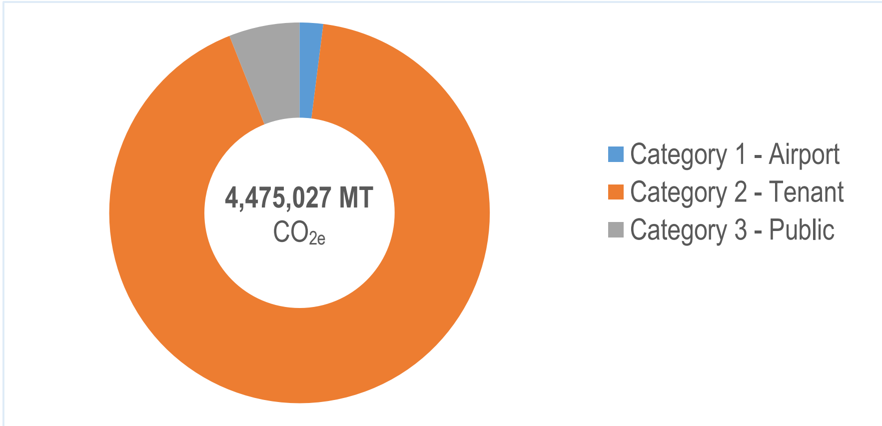
Figure 6. Contributors of GHG Emissions



*Other sources include contracted shuttles, construction vehicles, refrigerants, and the fire training facility.

Airport owned and controlled sources (i.e., Category 1) comprised only two percent of the total GHG emissions. **Figure 7** presents the percentage breakdown for the three categories.

Figure 7. 2013 GHG Emissions by Category



In 2013, PHL reduced its GHG emissions by 5,820 MT CO_{2e} as a result of waste management practices, by diverting materials from the landfill through recycling initiatives by the tenants and Airport (the Airport recycled a total of approximately 1,817 tons of material and sent 7,775 tons of material to the landfill).[22,23]

Compared to the 2006 GHG emission inventory, the 2013 inventory showed a reduction of approximately two percent. This is due in part to the Airport's emissions reduction initiatives as well as a decrease in passenger activity and aircraft operations over this timeframe. The difference in emissions is also due to slight differences in methodology, assumptions, and available data between the two analysis years. GHG emissions associated with Airport and public sources decreased from 2006 to 2013, whereas GHG emissions associated with tenants increased.

Compared to other large commercial hub airports in the northeastern United States, PHL's GHG emissions are quite similar in that Category 1 emissions typically range between two to four percent of the total inventory, Category 2 emissions typically range between 90 to 94 percent, and Category 3 emissions typically range between 2 to 8 percent.[24] **Figure 8** illustrates these findings.

Next steps and future initiatives to further reduce GHG emissions at PHL can include:

- Additional waste management practices, such as an expansion of the Airport's recycling program to include food waste and construction and debris materials.
- Transportation initiatives, such as Airport fleet vehicle improvements and incentives for tenants and the public to use alternative fuel vehicles.
- A variety of potential facility improvements to help reduce energy use in existing facilities and to maximize the benefit of new facilities.
- Operational improvements on the airside such as single-engine aircraft taxiing.

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[22] As compared to a scenario in which all waste is landfilled. See **Appendix C** for further details on waste management reduction emission calculations.

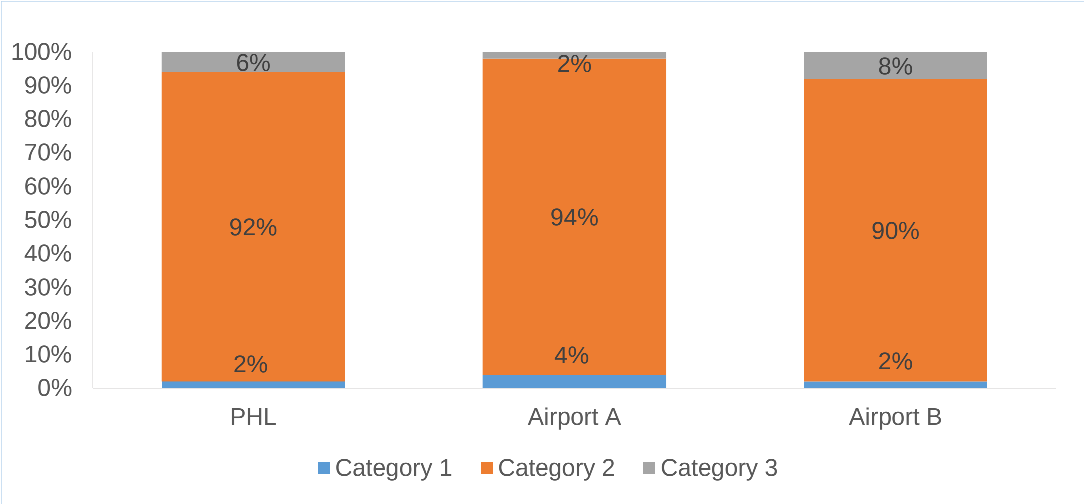
[23] Emissions estimates based on data available from the City of Philadelphia's Division of Aviation (DOA), US Airways, and Marketplace Philadelphia. Recycling quantities are not inclusive of all tenants at PHL.

[24] PHL's GHG emissions were compared to recently-prepared airport GHG emissions inventories for two large hub commercial airports located in the northeast of the United States (i.e., Airport A and B). Airport A had 361,343 operations and 14,531,990 enplanements and Airport B had 260,201 operations and 10,970,190 enplanements during the inventory year. It should be noted that the data presented in Figure 11 are approximations as it is difficult to compare precisely GHG emissions between airports because there are several factors (e.g., airport size, types of emissions sources, variations between emissions source activity levels, geographic location, and geographic extent of the GHG inventory boundary) that vary considerably between airports and that have a large bearing on a GHG emission inventory.

- Planning measures aimed at sustainability activities and GHG registries.

Furthermore, periodic updates to the Airport's GHG emissions inventory will allow for continued improvements in the identification, quantification, and management of emissions and associated energy usage.

Figure 8. PHL GHG Emissions Compared to Other Airports



Greenhouse Gas Emissions Inventory

Philadelphia International Airport
April 2015

Appendices

List of Appendices

A References

- City of Philadelphia, *Greenworks Philadelphia*, 2014 Progress Report, http://www.phila.gov/green/PDFs/Greenworksprogressreport.pdf.

- City of Philadelphia, *Local Action Plan for Climate Change*, April 2007, http://www.phila.gov/green/PDFs/Attachment1_Philadelphia_Local_Action_Plan_Climate_Change.pdf.

- City of Philadelphia, *Philadelphia's Greenhouse Gas Inventory for 1990, 1997, 2006 and 2010*, Supplement to "Local Action Plan for Climate Change", April 2007, http://www.phila.gov/green/PDFs/Attachement2_Philadelphias_Greenhouse_Gas_Inventory.pdf.

- Environmental Protection Agency, *Climate Leaders Greenhouse Gas Inventory Protocol Core Module Guidance, Optional Emissions from Commuting, Business Travel and Product Transport*, May 2008, http://www.epa.gov/climateleadership/documents/resources/commute_travel_product.pdf.

- Environmental Protection Agency, *Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment*, May 2008 [EPA-430-K-03-004b], http://www.epa.gov/climateleadership/documents/resources/mfgrfg.pdf.

- Environmental Protection Agency, *Emissions & Generation Resource Integrated Database (eGRID),* 9th edition Version 1.0, February 2014, http://www.epa.gov/climateleadership/documents/emission-factors.pdf.

- Environmental Protection Agency, *GHG Emission Factors Hub*, April 2014, http://www.epa.gov/climateleadership/documents/emission-factors.pdf.

- Environmental Protection Agency, *Motor Vehicle Emissions Simulator (MOVES)*, http://www.epa.gov/otaq/models/moves/.

- Environmental Protection Agency, *Motor Vehicle Emissions Simulator (MOVES) User Guide for MOVES2010b*, June 2012 [EPA-420-B-12-001b], http://www.epa.gov/otaq/models/moves/documents/420b12001b.pdf.

- Environmental Protection Agency, *Waste Reduction Model (WARM)*, Version 13, June 2014, http://epa.gov/epawaste/conserve/tools/warm/index.html.

- Federal Aviation Administration, *Emissions Dispersion Modeling System (EDMS)*, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/.

- Federal Aviation Administration, *United States Aviation Greenhouse Gas Emissions Reduction Plan*, June 2012, http://www.faa.gov/about/office_org/headquarters_offices/apl/environ_policy_guidance/policy/media/Aviation_Greenhouse_Gas_Emissions_Reduction_Plan.pdf.

- Intergovernmental Panel on Climate Change, *Guidelines for National Greenhouse Gas Inventories*, Volume 2, 2006, www.ipcc-nggip.iges.or.jp/public/gl/invs5.htm.

- Mayor's Office of Sustainability, City of Philadelphia, http://www.phila.gov/green/PDFs/Greenworksprogressreport.pdf.

- Pennsylvania Department of Environmental Protection, *Pennsylvania Climate Change Action Plan Update*, December 2013, http://files.dep.state.pa.us/Energy/Office%20of%20Energy%20and%20Technology/OETDPortalFiles/Climate%20Change%20Advisory%20Committee/Final_Climate_Change_Action_Plan_Update.pdf.

- Philadelphia International Airport, *2013 Annual Recycling Report*, June 2014.
- Philadelphia International Airport, *Environmental Stewardship Plan*, July 2008 http://www.phl.org/AboutPHL/Environmentalinitiatives/Documents/PHL%20Envtal%20Stewardship%20Plan%20Oct08.pdf.
- Philadelphia International Airport, *Greenhouse Gas Emissions Inventory*, Final Report June 2009, http://www.phl.org/AboutPHL/Environmentalinitiatives/SustainabilityInitiatives/Documents/GHGinventoryFinalSH.pdf.
- Transportation Research Board, ACRP Report 102, *Guidance for Estimating Airport Construction Emissions*, 2014 http://www.trb.org/ACRP/Blurbs/170234.aspx.
- Transportation Research Board, ACRP Report 11, *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*, 2009, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf.
- Transportation Research Board, ACRP Report 56, *Handbook for Considering Practical GHG Emission Reduction Strategies for Airports*, 2011, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_056.pdf.

B Terms and Concepts

Above Ground Level (AGL) - Height above ground elevation.

Airport Planning Category - Three airport planning categories are identified in *ACRP Report 11*. These categories are characterized by degrees of control that an airport operator may have and they are: *Category 1* – This category comprises of GHG emissions associated sources that are owned and controlled by the reporting entity (e.g., Airport Authority); *Category 2* – This category comprises of GHG emissions associated with sources owned and controlled by airlines and airport tenants; and *Category 3* – This category generally comprises GHG emissions associated with public sources associated with the airport and not owned/controlled by the Airport Authority and/or tenants.

Airport Tenants - Lessors, owners and/or occupiers of airport property that utilize the facilities or land for business purposes.

Auxiliary Power Units (APUs) - On-board engines that supply power to an aircraft while taxing and parked at the gate when the main engines are off.

Carbon Dioxide (CO_2) - The most prevalent GHG emitted when burning carbon-based fuels.

Carbon Dioxide Equivalents (CO_{2e}) - A quantity that describes, for a given GHG, the amount of CO2 that would have the same global warming potential, when measured over a specified timescale.

Clean Air Act (CAA) - The Federal law regulating air quality. The first CAA, passed in 1967, required that air quality criteria necessary to protect the public health and welfare be developed. Since 1967, there have been several revisions to the CAA. The CAA Amendments (CAAA) of 1990 represent the fifth major effort to address clean air legislation.

Construction Emissions - Emissions generated by construction activities and/or equipment that may have substantial temporary impact on local air quality.

Emission Factors - The relationship between the amount of emissions produced and the amount of raw material processed (e.g., in the case of GHGs, the amount of fuel burned, vehicle miles traveled, etc.).

Emission Inventory - A complete list of sources and rates of pollutant emissions within a specific area and time interval.

Emission Sources - The entity (or entities) that emit the emissions (e.g., motor vehicles, boilers, etc.).

Emissions and Dispersion Modeling System (EDMS) - A model designed to assess the air quality impacts of airport emission sources, particularly aviation sources, which consist of: aircraft, APUs, GSE, ground access vehicles, and stationary sources.

Fluorinated Gases - There are 3 main categories of fluorinated gases -hydrofluorocarbons (HFCs), perfluorocarbons (PFCs), and sulfur hexafluoride (SF_6). These are synthetic, powerful greenhouse gases (GHGs) that have no natural sources and only come from human-related activities and are emitted through a variety of industrial processes.

General Aviation (GA) - The operation of civilian aircraft for purposes other than commercial passenger transport, including personal, business, and instructional flying.

Global Warming Potential (GWP) - A relative measure of how much heat a GHG traps in the atmosphere when compared to CO2. GWP values of 1 for CO_2, 25 for CH_4, and 298 for N_2O (based on a 100 year period) were used.

Greenhouse effect - Gases that contribute to the greenhouse effect by absorbing infrared radiation (e.g., CO_2, N_2O, CH_4, etc.).

Greenhouse Gases (GHGs) - Gases that trap heat in the atmosphere. The most prevalent GHGs are CO_2, methane (CH_4), and nitrous oxide (N_2O), and fluorinated gases.

Ground Access Vehicle - Encompass motor vehicles traveling on- and off-airport roadways, within airport parking facilities, and idling along terminal curbsides (e.g., private autos, taxis/limos, shuttles, vans, buses, rental cars, etc.). Ground access vehicles exclude those GSE used for servicing the aircraft and airport.

Ground Power Unit (GPU) **-** Provides electrical power to aircraft during ground time.

Ground Support Equipment (GSE) - On-site airport vehicles and equipment designed to service aircraft while parked at the gate or when operating in the terminal area (e.g., baggage tugs, belt loaders, etc.).

Landing and Takeoff (LTO) - LTO refers to an aircraft's landing and takeoff cycle. One aircraft LTO is equivalent to 2 aircraft operations (1 landing and 1 takeoff). The standard L TO cycle begins when the aircraft crosses into the mixing zone as it approaches the airport on its descent from cruising altitude, lands and taxis to the gate. The cycle continues as the aircraft taxis back out to the runway for takeoff and climbout as its heads out of the mixing zone and back up to cruising altitude. The 5 specific operating modes in a standard LTO are: approach, taxi/idle-in, taxi/idle-out, takeoff, and climbout. Most aircraft go through this sequence during a complete standard operating cycle.

Methane (CH_4) - Methane is the second most prevalent GHG, emitted from industry, agriculture, and waste management activities.

Metric Tons - The standard reporting unit for GHG emissions expressed as MT (1 MT = 1.1 Short tons = 2,200 pounds).

Mixing Height - The height of the completely mixed portion of atmosphere that begins at the earth's surface and extends to a few thousand feet overhead where the atmosphere becomes fairly stable.

Mobile Source - A moving vehicle that emits pollutants. Such sources include airplanes, automobiles, trucks and ground support equipment

Refrigerants - A range of chemicals used for refrigeration and air conditioning that are comprised of substances possessing global warming characteristics (e.g., Freon, chlorofluorocarbons, etc.).

Scopes - For the purposes of determining ownership and control of GHG emissions, emission sources are categorized as either: *Scope 1* - emissions that are from sources that are owned and controlled by the reporting entity (i.e., Airport); *Scope 2* - emissions associated with the generation of purchased electricity consumed by the entity; or *Scope 3* - emissions that are a consequence of the activities of the entity, but occur at sources owned and controlled by another party (e.g., airport tenant).

Stationary Source - A source of pollutants which is immobile. Such sources include power plants, individual heater, incinerators, fuel tanks, Aircraft Rescue and Firefighting (ARFF) training, facilities and solvent degreasers, among others.

Vehicle Miles Traveled (VMT) - The sum of distances traveled by all motor vehicles in a specified region. VMT is equal to the total number of vehicle trips multiplied by the trip distance (measured in miles). This sum is used in computing an emission inventory for motor vehicles.

Waste Management - The solid waste generated at the airport and the recycling and solid waste disposal practices employed by the airport.

C Emissions Calculation Methodology

Presented in **Appendix C** are the overall data, assumptions, approach and methodology for preparing the 2013 greenhouse gas (GHG) emissions inventory for Philadelphia International Airport (PHL). GHG emissions sources addressed in the GHG inventory include the following, each of which are discussed individually in the forthcoming sections:

- Aircraft
- Auxiliary Power Units (APU)
- Ground support equipment (GSE)
- Ground Access Vehicles (GAV)
- Stationary Sources
- Electrical Usage
- Construction Equipment
- Refrigerant Usage
- Waste Management

Because in some instances operational data and information were not readily available, reasonable assumptions, third-party data and engineering judgment were applied in certain areas of the assessment. For those instances where data was available, the input data were either based on PHL records, data and information or derived from the latest version of the Federal Aviation Administration (FAA) Emissions and Dispersion Modeling System Version 5.1.4.1 (EDMS v.5.1.4.1).[1]

Aircraft

Aircraft activity levels (aircraft arrival and departure operations) and aircraft assignments for PHL were based on a data set obtained from the Airport Noise and Operations Monitoring System (ANOMS). The ANOMS output contains airline, aircraft type, tail number, operation type (i.e., arrival/departure), date and time of operation, and runway assignment.

As the ANOMS does not capture 100 percent of the aircraft operations based on transponder activity for certain aircraft classes, the aircraft fleet mix was adjusted (by aircraft category) to match the annual FAA's Air Traffic Activity Data System (ATADS) and/or the PHL Aviation Activity Reports. **Table C-1** contains the annual operations by aircraft category used in the emissions inventory.

Table C-1. Aircraft Operations

Aircraft Category	Operations
Air Cargo	12,688
Air Carrier	241,108
Air Taxi	175,426
General Aviation	13,784
Military	376

Source: PHL Airport Noise and Operations Monitoring System, FAA's Air Traffic Activity Data System (ATADS), and PHL Aviation Activity Report.

The FAA's EDMS v.5.1.4.1 was used to estimate fuel consumption from aircraft operating within the Landing/Take-Off cycle (LTO). One LTO is equivalent to 1 aircraft arrival and 1 departure operation, and includes the startup, taxi-out, take-off, climb-out, approach, and taxi-in operational modes. Estimated total aircraft fuel usage for 2013 was 396,070,850 gallons of Jet A and 16,000 gallons of Avgas based on airport fuel records.

[1] Federal Aviation Administration, Emissions and Dispersion Modeling System (EDMS) User's Manual, Version 5.1.4, June 2013, http://www.faa.gov/about/office_org/headquarters_offices/apl/research/models/edms_model/media/EDMS_5.1.4_User_Manual.pdf.

Aircraft Fleet Mix Determination

Aircraft activity levels (aircraft arrival and departure operations) and aircraft assignments were developed. Aircraft engine assignments were based on the EDMS default values or airline specific information. The combinations of airline/aircraft type/engine types operating at PHL were derived using the *JP Airline-Fleets International* 2012/2013 (JP Fleets)[2] that contain engine type information for each airline and cargo operator. Aircraft engine types specific to US Airways (America West), UPS, and Southwest Airlines, were modeled in EDMS, while default engine assignments were assumed for other airlines and cargo operators. For general aviation and military aircraft, the default engine type in EDMS was used. If a default engine type was not available in EDMS, the most common engine type for that particular aircraft type was assigned.

Tables C-2 through **C-6** contain the estimated 2013 annual aircraft operations along with the aircraft/engine combination and airline for air cargo, air carrier, air taxi, general aviation and military operations, respectively, used in the PHL emissions inventory.

Table C-2. Aircraft Fleet Mix and Operation - Air Cargo

Aircraft	Engine	Airline	Operations
Airbus A300F4-600 Series	CF6-80C2A5 (1GE020)	FedEx	466
Airbus A300F4-600 Series	PW4158	United Parcel Service	914
Airbus A310-200 Series	CF6-8C2A2 1862M39	FedEx	244
Boeing 757-200 Series	RB211-535E4 Phase 5	FedEx	274
Boeing 757-200 Series	RB211-535E4 Phase 5	United Parcel Service	4,278
Boeing 767-300 Series	CF6-80C2B6	United Parcel Service	2,946
Boeing DC-10-10 Series	CF6-6D	FedEx	898
Boeing MD-11	CF6-80C2D1F	FedEx	744
Boeing MD-11	PW4460	United Parcel Service	1,388
Boeing 767-200 Series	CF6-80A	Other	536
		Total	**12,688**

Table C-3. Aircraft Fleet Mix and Operation – Air Carrier

Aircraft	Engine	Airline	Operations
Airbus A319-100 Series	CFM56-5A5	Air Canada	56
Airbus A319-100 Series	CFM56-5B6/2	America West	19,126
Airbus A319-100 Series	CFM56-5A5	Delta Air Lines	1,022
Airbus A319-100 Series	V2524-A5	Spirit Airlines	266
Airbus A319-100 Series	V2524-A5	United Airlines	2,672
Airbus A319-100 Series	CFM56-5B7/3	Virgin America	832
Airbus A320-100 Series	CFM56-5-A1	America West	22,342
Airbus A320-100 Series	CFM56-5-A1	Delta Air Lines	1,054
Airbus A320-100 Series	CFM56-5-A1	Jet Blue	18
Airbus A320-100 Series	CFM56-5-A1	Spirit Airlines	1,218
Airbus A320-100 Series	V2524-A5	United Airlines	2,546

[2] These data comprise a comprehensive reference of the aircraft fleet for all known commercial aircraft operators including current registration, type, serial number, previous identity, date of manufacture, date of delivery, engine type and number, maximum take-off weight, configuration, fleet number, name, etc. for every aircraft weighing over 3,000 pounds. The database represents more than 6,000 operators and over 50,000 aircraft.

Aircraft	Engine	Airline	Operations
Airbus A320-100 Series	CFM56-5-A1	Virgin America	1,612
Airbus A321-100 Series	V2530-A5	America West	21,068
Airbus A330-200 Series	Trent 772	America West	4,164
Airbus A330-300 Series	PW4168-1D	America West	4,090
Boeing 717-200 Series	BR715A1-30 Improved fuel injector	AirTran Airways	6,390
Boeing 737-300 Series	CFM56-3-B1	Southwest Airlines	3,086
Boeing 737-400 Series	CFM56-3B-2	America West	5,952
Boeing 737-700 Series	CFM56-7B26 (8CM051)	Delta Air Lines	26
Boeing 737-700 Series	CFM56-7B22	Southwest Airlines	12,624
Boeing 737-700 Series	CFM56-7B20	AirTran Airways	330
Boeing 737-700 Series	CFM56-7B24	United Airlines	382
Boeing 737-800 Series	CFM56-7B26 (8CM051)	American Airlines	3,424
Boeing 737-800 Series	CFM56-7B26 (8CM051)	Delta Air Lines	1,926
Boeing 737-800 Series	CFM56-7B26 (8CM051)	Southwest Airlines	660
Boeing 737-800 Series	CFM56-7B26 (8CM051)	United Airlines	1,356
Boeing 737-900 Series	CFM56-7B26 (8CM051)	United Airlines	1,276
Boeing 757-200 Series	RB211-535E4 Phase 5	American Airlines	14
Boeing 757-200 Series	RB211-535E4 Phase 5	America West	7,566
Boeing 757-200 Series	PW2037 (4PW072)	Delta Air Lines	1,348
Boeing 757-200 Series	PW2037 (4PW072)	United Airlines	292
Boeing 767-200 Series	CF6-80C2B2	America West	4,486
Boeing 767-300 Series	RB211-524H	British Airways	516
Boeing 767-300 Series	PW4060 Phase III	Delta Air Lines	20
Boeing 777-200 Series	GE90-85B DAC I	British Airways	894
Bombardier CRJ-700	CF34-8C1	Mesa Airlines	1,058
Bombardier CRJ-700	CF34-8C1	Southeast Airlines	1,220
Bombardier CRJ-700	CF34-8C1	American Eagle	2,812
Bombardier CRJ-900	CF34-8C5 LEC (8GE110)	Mesa Airlines	820
Bombardier CRJ-900	CF34-8C5 LEC (8GE110)	Southeast Airlines	452
Bombardier CRJ-900	CF34-8C5 LEC (8GE110)	Pinnacle Airlines	1,374
Boeing DC-9-50 Series	JT8D-17 Reduced Emissions	Delta Air Lines	334
Embraer ERJ170	CF34-8E5 LEC (8GE108)	Air Canada	850
Embraer ERJ170	CF34-8E5 LEC (8GE108)	Republic Airlines	50,484
Embraer ERJ170	CF34-8E5 LEC (8GE108)	Sky Regional Airlines	794
Embraer ERJ170	CF34-8E5 LEC (8GE108)	Sky Regional Airlines	1,074
Embraer ERJ190	CF34-10E5 2253M21	Air Canada	44
Embraer ERJ190	CF34-10E6 SAC	America West	25,982
Embraer ERJ190	CF34-10E6 SAC	Jet Blue	2,120
Embraer ERJ190	CF34-10E6 SAC	Republic Airlines	22
Boeing MD-82	JT8D-219	American Airlines	2,088
Boeing MD-83	JT8D-219	American Airlines	2,370
Boeing MD-88	JT8D-219	Delta Air Lines	3,966
Boeing MD-90	V2528-D5	Delta Air Lines	4,712
Airbus A320-100 Series	CFM56-5-A1	Other	506

Aircraft	Engine	Airline	Operations
Airbus A330-300 Series	PW4168A Talon II	Other	54
Airbus A340-300 Series	CFM56-5C4	Other	578
Boeing 737-400 Series	CFM56-3C-1	Other	38
Boeing 737-700 Series	CFM56-7B20	Other	12
Boeing 737-800 Series	CFM56-7B27	Other	534
Boeing 737-900 Series	CFM56-7B26 (8CM051)	Other	302
Bombardier CRJ-700	CF34-8C1	Other	842
Embraer ERJ170	CF34-8E5 LEC (8GE108)	Other	38
Boeing 737-400 Series	CFM56-3C-1	Other	64
Boeing 737-700 Series	CFM56-7B20	Other	14
Bombardier CRJ-700	CF34-8C1	Other	584
Embraer ERJ170	CF34-8E5 LEC (8GE108)	Other	312
		Total	**241,108**

Table C-4. Aircraft Fleet Mix and Operation – Air Taxi

Aircraft	Engine	Airline	Operations
Bombardier CRJ-200	CF34-3B	Air Wisconsin	79,790
Bombardier CRJ-200	CF34-3B	Pinnacle Airlines	4,478
Bombardier CRJ-200	CF34-3B	PSA Airlines	13,114
Bombardier de Havilland Dash 8 Q100	PW120A	Piedmont Airlines	64,262
Bombardier de Havilland Dash 8 Q300	PW123	Piedmont Airlines	570
Embraer ERJ145	AE3007A1/1 Type 3 (reduced emissions)	Southeast Airlines	284
Embraer ERJ145	AE3007A1/1 Type 3 (reduced emission)	Chautauqua Airlines	5,686
Embraer ERJ145-XR	AE3007A1E	Southeast Airlines	82
Embraer EMB120 Brasilia	PW118	NetJets	48
Bombardier Global Express	BR700-710A2-20	NetJets	16
Bombardier de Havilland Dash 8 Q200	PW123D	Other	86
Bombardier de Havilland Dash 8 Q300	PW123B	Other	360
Embraer ERJ145	AE3007A1/1 Type 3 (reduced emissions)	Other	3,376
Gulfstream G400	TAY 611-8C	Other	22
Bombardier de Havilland Dash 8 Q100	PW121	Other	18
Bombardier Global Express	BR700-710A2-20	Other	176
Embraer EMB110 Bandeirante	PT6A-34	Other	66
Embraer EMB120 Brasilia	PW118	Other	128
Embraer ERJ135	AE3007A1E	Other	120
Falcon 7X	PW307A TALON II (11PW100)	Other	126
Gulfstream G300	TAY Mk611-8	Other	84
Gulfstream G400	TAY 611-8C	Other	1,292
Gulfstream G500	BR700-710A1-10 (4BR008)	Other	730
Raytheon Super King Air 200	PT6A-42	Other	288

Aircraft	Engine	Airline	Operations
Raytheon Super King Air 300	PT6A-60A	Other	224
		Total	**175,426**

Table C-5. Aircraft Fleet Mix and Operation – General Aviation

Aircraft	Engine	Operations
Raytheon Beechjet 400	JT15D-5. -5A. -5B	96
Cessna 560 Citation V	PW530	214
Cessna 560 Citation V	JT15D-5. -5A. -5B	1042
Cessna 680 Citation Sovereign	PW306B	368
Cessna 750 Citation X	AE3007C Type 2	412
Dassault Falcon 2000	PW308C	252
Israel IAI-1126 Galaxy	PW306A	258
Hawker HS-125 Series 1	TFE731-3	198
Bombardier Challenger 300	HTF7000 (AS907-1-1A)	12
Bombardier Challenger 600	ALF 502L-2	14
Pilatus PC-12	PT6A-67	110
Bombardier Challenger 300	HTF7000 (AS907-1-1A)	698
Bombardier Challenger 600	ALF 502L-2	672
Bombardier Learjet 31	TFE731-2-2B	186
Bombardier Learjet 35	TFE731-2-2B	714
Bombardier Learjet 40	TFE731-2-2B	138
Bombardier Learjet 45	TFE731-2-2B	424
Bombardier Learjet 55	TFE731-3	82
Bombardier Learjet 60	TFE731-2/2A	670
Cessna 172 Skyhawk	IO-360-B	88
Cessna 182	IO-360-B	74
Cessna 208 Caravan	PT6A-114A	110
Cessna 310	TIO-540-J2B2	54
Cessna 501 Citation ISP	JT15D-1 series	56
Cessna 525 CitationJet	JT15D-1 series	368
Cessna 550 Citation II	JT15D-4 series (1PW036)	224
Cessna 560 Citation V	JT15D-5. -5A. -5B	766
Cessna 650 Citation III	TFE731-3	96
Cessna 680 Citation Sovereign	PW306B	128
Cessna 750 Citation X	AE3007C Type 2	262
Cirrus SR22	TIO-540-J2B2	198
Dassault Falcon 10	TFE731-2-2B	60
Dassault Falcon 2000	PW308C	754
Dassault Falcon 50	TFE731-3	292
Dassault Falcon 900	TFE731-3	460
Gulfstream G150	TFE731-3	112
Gulfstream G550	BR700-710C4-11	126
Hawker HS-125 Series 1	TFE731-3	692
Israel IAI-1125 Astra	TFE731-3	54

Aircraft	Engine	Operations
Israel IAI-1126 Galaxy	PW306A	100
Mitsubishi MU-2	TPE331-1	140
Piaggio P.180 Avanti	PT6A-66	100
Pilatus PC-12	PT6A-67B	132
Piper PA-28 Cherokee Series	O-360-B	54
Piper PA-31 Navajo	TIO-540-J2B2	106
Piper PA-32 Cherokee Six	TIO-540-J2B2	76
Piper PA-42 Cheyenne Series	TPE331-14B	80
Raytheon Beech Baron 58	TIO-540-J2B2	354
Raytheon Beech Bonanza 36	TIO-540-J2B2	116
Raytheon Beechjet 400	JT15D-5. -5A. -5B	552
Raytheon King Air 100	TPE331-6	142
Raytheon King Air 90	PT6A-21	94
Robinson R22	O-320	132
Rockwell Commander 690	TPE331-10	72
	Total	**13,784**

Table C-6. Aircraft Fleet Mix and Operation - Military

Aircraft	Engine	Operations
Boeing C-17A	F117-PW-100	376
	Total	**376**

Aircraft Emission Factors

EDMS contains a database of aircraft/engine-specific criteria pollutant emission factors based on engine manufacturer, model, and operational mode. The level of aircraft-related emissions is reflective of the time that an aircraft operates in each of the operational modes with the entire cycle referred to as an LTO cycle. An LTO cycle consists of the following operational modes:

- *"Taxi/idle"* includes the time an aircraft taxis between the runway and a terminal, and all ground-based delay incurred through the aircraft route. The taxi/idle-delay mode includes the landing roll, which is the movement of an aircraft from touchdown through deceleration to taxi speed or full stop.
- *"Approach"* begins when an aircraft descends below the atmospheric mixing height and ends when an aircraft touches down on a runway.
- *"Takeoff"* begins when full power is applied to an aircraft and ends when an aircraft reaches approximately 500 to 1,000 feet. At this altitude, pilots typically power back for a gradual ascent.
- *"Climb out"* begins when an aircraft powers back from the takeoff mode and ascends above the atmospheric mixing height.

With the exception of ground-based taxi-in/taxi-out including apron idling and departure runway queue delay, the default operating times in EDMS were used. Consistent with the *ACRP Report 11 Guidebook*[3], the GHG emissions inventory assessed emissions with a mixing height of 3,000 feet.

[3] Transportation Research Board, ACRP Report 11, *Guidebook on Preparing Airport Greenhouse Gas Emissions Inventories*, 2009, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_011.pdf.

Fuel usage within the aircraft engine startup mode was estimated based on published guidance for the engine startup fuel flow rate.[4] Based on the number of non-piston aircraft operations and this fuel flow rate, the engine startup fuel usage was determined and with the use of the aircraft GHG emission factors GHG emissions were developed. Estimated aircraft engine startup fuel usage for 2013 was 258,752 gallons of Jet A.

Aircraft Taxi Times

PHL-specific times-in-mode for taxi-in and taxi-out were developed from the Bureau of Transportation Statistics (BTS)[5] databases. The BTS provides airport average taxi-in and -out times of 6.35 and 21.44 minutes, respectively, for 2013. The average taxi-in and -out times for US Airways/America West of 5.95 and 22.78 minutes were reported by BTS. Average taxi-in and -out times for other airlines were also included in the analysis. **Table C-7** documents the aircraft taxi times.

Table C-7. Aircraft Taxi Times

Airline	Taxi In	Taxi Out
US Airways/America West	5.95	22.78
Southwest Airlines	6.56	16.40
Delta Air Lines	7.08	20.79
United Airlines	7.02	19.93
American Airlines	6.20	21.96
AirTran Airways	7.77	18.66
American Eagle	5.47	21.30
Virgin America	8.75	23.70
Jet Blue	6.37	19.04
Southeast Airlines	6.00	14.15
Mesa Airlines	6.31	19.08
Other	6.35	21.44

Source: Bureau of Transportation Statistics, 2014.

Single Engine Taxi

A methodology[6,7,8] was developed to account for single-engine taxi procedures during the taxi-in or -out modes. The single-engine taxi operations were assigned to Delta Air Lines operations only. Of note, single-engine taxi challenges include: 1) excessive thrust and associated issues; 2) maneuverability problems, particularly related to tight taxiway turns and weather; 3) problems starting the second engine; and 4) distractions and workload issues. Thus, single-engine taxiing does not occur during each aircraft operation, and when it does occur, it does not occur during the entire operation, and it occurs far less often during taxi-out. To account for these variances, the following assumptions were developed based on available information such as aircraft pilot surveys:

- Practiced during 75 percent of the arrivals. When practiced, conducted 3.1 minutes after landing (to account for engines cool down period).
    - Thus, the 2013 taxi-in time of 6.35 minutes would involve 3.1 minutes of required full engine usage; of the remaining 3.25 minutes. A single-engine taxi procedure would be employed 75 percent of the time during aircraft arrival operations. The resultant effective taxi-in time would be 5.13 minutes.

[4] ICAO/CAEP Working Group 3, May 5, 2006, Engine Starting Emissions.
[5] Bureau of Transportation Statistics, http://apps.bts.gov/xml/ontimesummarystatistics/src/index.xml.
[6] A Survey of Airline Pilots Regarding Fuel Conservation Procedures for Taxi Operations, Massachusetts Institute of Technology.
[7] *Opportunities for Reducing Surface Emissions through Airport Surface Movement Optimization,* Massachusetts Institute of Technology, 2008.
[8] Analysis of Emissions Inventory for Single Engine Taxi-out Operations, Center for Air Transportation Systems Research.

- Practiced during 10 percent of the departures. When practiced, conducted 4.6 minutes before takeoff (to account for engines warm up period).
    - Thus, the 2013 taxi-out time of 21.44 minutes would involve 4.6 minutes of required full engine usage, of the remaining 16.84 minutes; a single-engine taxi procedure would be employed 10 percent of the time during aircraft departure operations. The resultant taxi-out time would be 20.60 minutes.
- Practiced with aircraft with 2 engines, but not aircraft with more than 2 engines.
- Applicable for commercial and cargo aircraft operations only.

Therefore, the resulting taxi times (relative to the use of 2 engines) at PHL during 2013 would be reduced from 6.35 to 5.13 minutes (taxi-in) and from 21.44 to 20.60 minutes (taxi-out), or a 7 percent reduction in total taxi time (and fuel usage during taxiing) for applicable aircraft operations. As a result of single engine taxi practices, approximately 1,569,994 gallons of jet fuel were saved during 2013; resulting in the reduction of 15,448 metric tons of CO_{2e} emissions or a 3 percent reduction in aircraft taxi emissions.

Auxiliary Power Units

APUs are small turbine engines used by many commercial jet aircraft to start the main engines and provide electrical power to aircraft radios, lights, and other equipment; and to power the onboard air conditioning (heating and cooling) system when the main jet engines are off. When an aircraft arrives at a terminal gate, the pilot has the option of shutting off power to the main jet engines and operating the onboard APU, which is fueled by the aircraft's jet fuel. Alternately, an aircraft can receive 400 Hz gate power and pre-conditioned air (PCA) from mobile ground power units (GPU) and air conditioning equipment, or receive electrical power and PCA from connections at the gate. In most cases, gate power connections are built into the passenger loading bridge used to connect the terminal building to the aircraft for loading and unloading passengers.

At PHL, Concourses A, B, C, D, E, and F have gate power and PCA at most available gate positions (110 of the 124 gates). At gates with gate power and PCA, APUs would tend to be used less often and/or for a reduced duration. Based on default estimates, gates without gate power and PCA would require an APU to operate for a minimum of 13 minutes on arrival and 13 minutes on departure. Gates with gate power and PCA would require an APU to operate for a minimum of 3.5 minutes on arrival and 3.5 minutes on departure. For general aviation, cargo, and military operations, default APU operating times (13 minutes on arrival and 13 minutes on departure) were assumed, where applicable. Of note, many general aviation aircraft do not have APUs. The fuel usage was estimated based on manufacturer fuel flow rates for respective APU (typically from 50 to 860 pounds per hour) or other appropriate methods. Estimated APU fuel usage in 2013 was 951,905 gallons of Jet A.

APU are categorized as *Category 2* (Scope 3) under the *ACRP Report 11 Guidebook* and are owned and controlled by the airline tenants. The GHG emissions were developed using Method 1, that is, APU-specific fuel consumption along with Jet A GHG emission factors.

Ground Support Equipment

GSE is a term used to describe the vehicles that service aircraft after arrival and before departure at an airport. The number, types of GSE, fuel type, and operational times that are used to service each category of aircraft were based on information provided by the airlines and developed during a site visit.[9] Emissions from these sources are based on the number and type of equipment used to service each aircraft along with the amount of time the equipment is in use per aircraft landing-takeoff cycle. The types of GSE at PHL include aircraft tugs, baggage tugs, fuel trucks, food trucks, cargo trailers, water trucks, lavatory trucks, cabin service, belt loaders, and cargo loaders. GSE fuel usage is tracked by ASIG for some airlines (such as US Airways and Piedmont) and was used

[9] A ground support equipment (GSE) survey was performed Philadelphia International Airport (PHL) in order to identify all GSE activity servicing a variety of aircraft operations at the airport. The survey was conducted by KM Chng Environmental Inc. in April 2004 in relation to the Environmental Impact Statement (EIS) of the Runway 17-35 Extension project.

to determine the GHG emissions. For the remaining airlines and other aircraft, the fuel usage was determined by using EDMS default GSE fleet mix and operating times based on the survey completed for the CEP Environmental Impact Statement. Estimated airline GSE fuel usage in 2013 was 1,168,914 gallons of diesel and 485,141 gallons of gasoline. Airport snow removal equipment fuel usage was determined based on the hours of operation and the type of equipment (i.e., snow plow, loader) and the equipment fuel usage rate. Estimated airline GSE fuel usage in 2013 was 101,546 gallons of diesel.

GSE are categorized as either Category 1 or 2 emissions (depending on the owner) and Scope 1 or 3 (depending on operational boundary) but are mostly airline owned/controlled with the exception of some GSE which are Airport owned/controlled. For this assessment, GSE were categorized as Category 2 (Scope 3) emissions under airline/tenant owned/controlled and the GHG emissions were developed using Method 2 for GSE of the *ACRP Report 11 Guidebook*.

Ground Access Vehicles

Ground access vehicles (GAV) consist of traffic volumes of airport-related motor vehicles (e.g., patrons, employees, tenants, shuttles, taxis, and deliveries, etc.) operating on the internal airport roadway network, on-site parking facilities as well as off-airport roadways.

Ground access vehicles are either owned by the airport and generally service the Airport vicinity, and/or are owned by the airport, tenants, and the public and service a wide geographical area.

GAV are categorized as either Category 1, 2 or 3 emissions (depending on the owner) and Scope 1 or 3 (depending on operational boundary) but are mostly tenant/public owned/controlled with the exception of some GAV which are Airport owned/controlled. For this assessment, the majority of the GAV emissions were categorized as Category 3 (Scope 3) under tenant/public owned/controlled and the GHG emissions were developed using Method 2 for GSE of the *ACRP Report 11 Guidebook*.

As previously mentioned, motor vehicle activity occurs within on-airport roadways, parking facilities, and off-airport roadways. The following modes of transportation were included in the PHL GHG emissions inventory:

- Fleet Vehicles
- Employee Vehicles
- Parking Facilities
- Vehicles On-Airport Roadways
- Vehicles Off-Airport Roadways
- Contracted Shuttle Buses
- SEPTA – Public Transit

The following section describes each modes of transportation and how their emissions were developed.

Fleet Vehicles

Fleet vehicles include tenant and airport-owned vehicles traveling within the airport boundaries. Data was based on gasoline and biodiesel fuel usage and was consistent with the 2013 City Government GHG Emissions Inventory. For 2013, the airport and tenant fleet vehicles gasoline usage was 77,608 and 32,754 gallons, respectively. For the airport and tenant fleet vehicles biodiesel usage was 49,054 and 18,218 gallons, respectively.

Employee Vehicles

Employee vehicles include both airport and tenant employee vehicles travelling on- and off-airport roadways. Data was based on vehicle miles travelled derived from number of employees, an estimated passengers per vehicle of 1.08, and an average travel roundtrip distance. In 2013, PHL employed a total of 1,027 and 18,584 airport and tenant employees, respectively. Airport employee were assumed to travel a distance of 28 miles per roundtrip and tenant employees were assumed to travel a distance of 40 miles per roundtrip. This data was based on employee zip code data provided by PHL. Airport and tenant employee VMT amounted to 5,791,139 and 149,704,444 miles, respectively.

Parking Facilities

Parking emissions are a compound function of how many vehicles are entering and/or exiting parking facilities within the airport and the distance they travel to access and egress the parking area. This category includes airport/tenant employee and passenger vehicles using airport parking facilities. VMT was derived by vehicle ticket counts within the different parking areas (i.e., employee lot, economy lot, garage parking and short-term parking) and assuming vehicles travel on average a distance of approximately 0.25 mile. Airport/tenant employee and passenger VMT on parking facilities amounted to 92,500 and 558,527 miles, respectively.

Vehicles: On-Airport Roadways

Vehicles travelling on-airport roadways consist of passenger autos, taxis, limousine/sedan services, rental car shuttles, parking courtesy shuttles, hotel shuttles, van services, charter buses, small service trucks, rental cars, and a miscellaneous category called "other". The majority of the data was based on VMT derived from airport traffic counts by vehicle classification provided by PHL. For those vehicles (i.e., passenger autos, taxis, limousine/sedan services, hotel shuttles, van services, charter buses, and rental cars) that travel both on- and off-airport roadways it was assumed that 3 miles out of the total roundtrip distance are within airport roadways. For those vehicles (i.e., parking courtesy shuttles, small service trucks and the miscellaneous category called "other") that travel only within airport roadways a 10 mile travel distance was assumed. Additionally, rental car shuttles and rental car data was based on annual fuel usage and the number of rental car transaction per rental car agency (i.e., Hertz, Dollar, Avis and Budget), respectively.

Vehicles: Off-Airport Roadways

Vehicles travelling off-airport roadways includes passenger autos, taxis, limousine, hotel shuttles, van services, charter buses, and rental cars. The majority of the data was based on VMT derived from airport traffic counts by vehicle classification provided by PHL. Assumed travel distance for specific type of vehicle such as 44 miles for passenger trips and charter bus, 5 miles for taxis and hotel shuttles, 23 miles for van service, and 17 miles for limousine/sedan services. Additionally, rental car data was based on the number of rental car transaction per rental car agency (i.e., Hertz, Dollar, Avis and Budget) and assuming a travel distance of approximately 117 miles.

Contracted Shuttle Buses

Contracted shuttle buses includes shuttles that provide airport/tenant employee and passenger transportation to and from airport parking lots. Assumed these buses to include First Transit servicing both passengers and employees and the COBUS 3000 leased by US Airways servicing only passengers. Data provided by PHL and based on 2013 fuel usage. Diesel fuel usage data amounted to 231,485, 115,742, and 58,000 gallons for First Transit (employee service), First Transit (passenger service), and the COBUS 3000, respectively.

SEPTA Public Transit

The Southeastern Pennsylvania Transportation Authority (SEPTA) is a metropolitan transportation authority that operates various forms of public transit. For the PHL emissions inventory SEPTA public transit servicing the airport (i.e., Commuter Rail and Bus Lines) was included. Annual passenger miles were based on ridership and the distance from farthest station/stop servicing the airport. VMT for the SEPTA rail and bus service amounted to 153,599,420 and 83,605,800 miles, respectively.

Stationary Sources

Stationary sources such as boilers, heaters, generators, and fire training facility were included in the analysis. These sources are generally owned and controlled by the Airport. Tenant owned stationary sources would be expected to be minimal. For 2013, diesel usage for the generators was 8,330 gallons. For the boilers and heaters, the natural gas usage was 337.44 million cubic feet.[10] The fire training facility used 19,500 gallons of propane.

Stationary sources are categorized as *Category 1* (Scope 1) and are under the ownership/control of the Airport. The GHG emissions were developed using Method 1 for stationary sources of the *ACRP Report 11 Guidebook*.

[10] This source category also includes door heaters, roof heaters, air handlers, etc. For a detailed list of sources using natural gas see PHL's Synthetic Minor Operating Permit No. S12-041.

Electrical Usage

During 2013, electrical consumption was 167,419,900 kilowatts of which 88,537,876 kilowatts was directly related to airport operations, and 78,882,024 kilowatts was related to tenant operations. The split of airport and tenant usage was based on the square footage attributed to those entities.

The GHG emission factor for electrical usage is based on data from U.S. EPA's 2010 eGRID[11]. The analysis used a value of 1,000 pounds of CO_2 per megawatt, 27 pounds of CH_4 per gigawatt, and 15 pounds of N_2O per gigawatt.

For this assessment, electrical consumption was categorized as Category 1 and 2 (Scope 2) emissions under airport/tenant owned/controlled and the GHG emissions were developed using the methodology described in the *ACRP Report 11 Guidebook*.

Construction Equipment

Construction activities are temporary and variable depending on project location, duration and level of activity. These emissions occur predominantly in the engine exhaust from the operation of construction equipment and vehicles (e.g., scrapers, dozers, trucks, etc.), but are also attributed to fugitive dust produced from construction materials staging, demolition and earthworks activities, and asphalt paving operations.

Construction equipment typically utilized in airport development projects comprises both on-road (i.e., road-licensed) and off-road equipment. The former category of vehicles are used for the transport and delivery of supplies, material and equipment to and from the site, and also include construction worker vehicles. The latter categories of equipment are operated on-site for activities such as paving, utility installation, site clearing and fill.

During 2013 there were 16 construction projects occurring in various stages of completion at PHL. Only 2 out of the 16 projects were included in the PHL emissions inventory. These projects include: 1) Installation of 5 GPUs and electrical receptacles at maintenance hangar, and 2) Addition of a high speed taxiway for Runway 27R and realignment of Taxiway T. The other remaining projects are tended to be minor or at the beginning/end of completion and thus comprise of only minor construction-related activities and therefore not included in the PHL emissions inventory.

Table C-8. Construction Projects

Construction Projects
Runway 9L/27R Resurfacing
Substation Rehabilitation
Runway 17/35 Extension
US Airways Maintenance Hanger- 5 Ground Power Units
Catering Gate 8
Taxiway – High Speed Exit
Airfield Lighting/Signage System Upgrade
Terminal Roof Replacement
Mechanical Room Rehabilitation
Central Utility Building – New Cooling Tower
Street Lighting and Sign Lighting Improvements
Landscape Irrigation Upgrade
Taxiway L Extension – Stockpile Removal
Taxiway L Extension – Wetland Mitigation
Slab Buckling / Repairs – Terminal B and D
Gate hardening

Source: PHL, 2014.

[11] Environmental Protection Agency, Emissions & Generation Resource Integrated Database (eGRID), 9th edition Version 1.0, February 2014, http://www.epa.gov/climateleadership/documents/emission-factors.pdf.

The Airport Construction Emissions Inventory Tool (ACEIT) within *ACRP Report 102*[12] was used to estimate emissions from the 2 construction projects mentioned above. Construction project footprint and cost were used to estimate construction activities and equipment within the ACEIT and default emission factors were assigned based on location of project. ACEIT uses default emission factors derived from EPA-approved emissions models for non-road construction equipment and on-road vehicles.

Refrigerant Usage

GHG emissions from the use of refrigeration can be associated with airport activities, but are not considered to be significant at PHL. GHG emissions associated with refrigerant usage at PHL were estimated using the screening methodology per *The Climate Registry, General Reporting Protocol Version 1.1 (May 2008) guidelines*[13]. The method for computing GHG emissions from refrigerants is based on material balancing, which takes into account the charging, operating, and disposal of refrigerants.

The screening method is intended for entities that don't own or operate a significant amount of equipment that use hydrofluorocarbons (HFCs) or perfluorocarbons (PFCs), but may own or operate Heating, Ventilating, and Air-Conditioning units, refrigerators, commercial air conditioning units or appliances, motor vehicles, fire extinguishers, etc. Typically the fugitive emissions from these sources represent less than 5 percent of an inventory and thus, simplified methods can be used to conservatively estimate these emissions. **Table C-9** displays the refrigerant units at PHL.

Table C-9. Refrigerant Units

Equipment Type	Refrigerant Type	Equipment Size	Location
Chillers #3 and #4	R-11	540 Pounds Refrigerant Charge	Central Utility Building

Source: PHL, 2014.

Waste Management

GHG emissions related to the waste management practices at PHL were estimated using U. S. EPA's Waste Reduction Model (WARM)[14], per the guidelines of the *ACRP Report 11 Guidebook*. In 2013, the Airport recycled a total of 1,817 tons of material and sent 7,775 tons of material to the landfill.

Results from WARM do not represent actual emissions, but rather describe the airport's emission reductions in metric tons of CO_2 equivalent (CO_{2e}), across a wide range of material types commonly found in municipal solid waste. The model estimates the difference in emissions between a scenario which assumes all waste is landfilled and PHL's actual waste management conditions (in which portions of waste are either recycled, combusted, composted, and/or landfilled).

Emissions from the transportation of the waste to the landfill are also incorporated into WARM. The default transportation distance of 20 miles was used. Using information published in the PHL 2013 Annual Recycling Report, waste materials were further broken down by the material types listed in **Table C-10**. This data also presents the inputs to WARM.

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[12] Transportation Research Board, ACRP Report 102, Guidance for Estimating Airport Construction Emissions, 2014 http://www.trb.org/ACRP/Blurbs/170234.aspx.

[13] Environmental Protection Agency, Direct HFC and PFC Emissions from Use of Refrigeration and Air Conditioning Equipment, May 2008 [EPA-430-K-03-004b], http://www.epa.gov/climateleadership/documents/resources/mfgrfg.pdf.

[14] Environmental Protection Agency, Waste Reduction Model (WARM), Version 13, June 2014, http://epa.gov/epawaste/conserve/tools/warm/index.html.

Table C-10. Waste Generation Breakdown

Type of Waste	Tons	Waste Management
Branches	40.6	Landfilled
Corrugated Containers	10.4	Recycled
Dimensional Lumber	40.6	Landfilled
Glass	40.6	Landfilled
Mixed Metals	3.4	Recycled
Mixed MSW	7624.5	Landfilled
Mixed Recyclables	1775.7	Recycled
Mixed Recyclables	29.0	Landfilled
Office Paper	8.7	Recycled
Personal Computers	19.3	Recycled
Subtotal Recycled	**1,817**	
Subtotal Landfilled	**7,775**	
Grand Total	**9,593**	

Source: PHL, 2014.

In 2013, according to the scenario run in the WARM, PHL reduced its GHG by 5,820 metric tons of CO_{2e} as a result of waste management practices to divert materials from the landfill through recycling initiatives by the tenants and Airport. The negative values reported by the model indicate that there is an environmental benefit as a result of the Airport's recycling program.

Emission Factors

Table C-11 summarizes the emission factors used in the computation of PHL's GHG emissions inventory.

Table C-11. Emission Factors

Fuel	CO_2	N_2O	CH_4	Units	Source
Jet A	21.50	0.00066	-[1]	lb/gallon	EPA[2]
AvGas	18.32	0.00024	0.01556	lb/gallon	EPA[2]
Diesel	22.51	0.00060	0.00130	lb/gallon	EPA[2]
Biodiesel	20.83	0.00060	0.00130	lb/gallon	EPA[2]
Gasoline	19.36	0.00050	0.00110	lb/gallon	EPA[2]
Propane	12.61	0.00011	0.00060	lb/gallon	EPA[2]
Natural Gas	120.02	0.00023	0.00226	lb/1000 ft^3	EPA[2]
Electricity	1	1.53E-05	2.71E-05	lb/kw	EPA[3]
Automobiles	522	0.00800	0.01060	g/mile	MOVES[4]
Shuttles	620	0.01300	0.01850	g/mile	MOVES[4]
Bus	1246	0.00330	0.02220	g/mile	MOVES[4]

1. Contributions of CH_4 emissions from commercial aircraft are reported as zero. Years of scientific measurement campaigns conducted at the exhaust exit plane of commercial aircraft gas turbine engines have repeatedly indicated that CH_4 emissions are consumed over the full emission flight envelope [Reference: *Aircraft Emissions of Methane and Nitrous Oxide during the Alternative Aviation Fuel Experiment*, Santoni et al., Environ. Sci. Technol., July 2011, Volume 45, pp. 7075-7082]. As a result, the USEPA published that: "…*methane is no longer considered to be an emission from aircraft gas turbine engines burning Jet A at higher power settings and is, in fact, consumed in net at these higher powers."* [Reference: USEPA, *Recommended Best Practice for Quantifying Speciated Organic Gas Emissions from Aircraft Equipped with Turbofan, Turbojet, and Turboprop Engines*, May 27, 2009 [EPA-420-R-09-901], http://www.epa.gov/otaq/aviation.htm]. In accordance with the following statements in the *2006 IPCC Guidelines* (IPCC 2006), the FAA does not calculate CH4 emissions for either the domestic or international bunker commercial aircraft jet fuel emissions inventories. *"Methane (CH4) may be emitted by gas turbines during idle and by older technology engines, but recent data suggest that little or no CH4 is emitted by modern engines." "Current scientific understanding does not allow other gases (e.g., N_2O and CH_4) to be included in calculation of cruise emissions."* (IPCC 1999).
2. U.S. EPA, GHG Emissions Factors Hub (April 2014), www.epa.gov/climateleadership/inventory/ghg-emissions.html.

3. U.S. EPA, Emissions & Generation Resource Integrated Database (eGRID) 9th edition Version 1.0, February 2014, http://www.epa.gov/climateleadership/documents/emission-factors.pdf.
4. U.S. EPA, MOVES2010b, http://www.epa.gov/oms/models/moves.

Global Warming Potentials

The GHG emissions results were converted to CO_2 equivalent values using the Global Warming Potential (GWP) values of 1 for CO_2, 25 for CH_4, and 298 for N_2O (based on a 100 year period) as presented in the IPCC's Assessment Report.[15] For refrigerants, the GWP for R-11 of 4,000 was used.

[15] Fourth Assessment Report of the Intergovernmental Panel on Climate Change, Cambridge University Press, New York City, NY. 2007.

D Potential GHG Reduction Measures

Appendix D lists potential GHG reduction measures that can be implemented at PHL. This information was derived from the AirportGEAR tool within ACRP Report 56 – *Handbook for Considering Practical GHG Emission Reduction Strategies for Airports*[16]. These measures are organized based on airfield design and operations, business planning, construction, carbon sequestration, energy management, GSE, ground transportation, materials and embedded energy, operation and maintenance, performance measurement , renewable energy (on-site), and refrigerants sources.

Table D-1. List of Potential Greenhouse Gas Reduction Strategies

ID	Greenhouse Gas Reduction Strategies
	Airfield Design and Operations
AF-01	Provide Infrastructure for Pre-Conditioned Air (PCA) and Ground Power
AF-02	Minimize the Use of Auxiliary Power Units (APUs)
AF-03	Design Airside Layout to Reduce Aircraft Delay and Surface Vehicle Congestion
AF-04	Design Runways, Taxiways, Ramps & Terminals to Reduce Aircraft Taxiing Distances
AF-05	Consider Longer Runways to Reduce the Use of Reverse Thrust
AF-06	Install or Expand Hydrant Fueling System
AF-07	Provide Fixed Gate Infrastructure for Aircraft Underground Supply and Evacuation Systems
AF-08	Create Partnerships with Intercity Rail Services to Optimize Passenger and Cargo Movement
AF-09	Implement Emission-based Incentives and Landing Fees
AF-10	Install a Jet Fuel Pipeline
AF-11	Support Optimized Departure Management on Existing Runways
AF-12	Support Modernization of Air Traffic Management (ATM)
AF-13	Support the Development of Alternative Fuels for Aircraft
AF-14	Support Single/Reduced Engine Taxiing
AF-15	Support Alternative Passenger Boarding Procedures
AF-16	Support Push Back Tugs to Transport Planes to Taxiways, Runway Ends
AF-17	Support Fuel Efficiency Targets for Aircraft
AF-18	Support the Use of Paperless Ticket Technology
	Business Planning
BP-01	Use Greenhouse Gas Impact Evaluations as Decision-Making Criteria
BP-02	Develop an Airport Expansion and Development Greenhouse Gas Emission Policy
BP-03	Develop a Climate Action Plan (CAP)
BP-04	Develop Climate Change and Energy Communication Materials and/or Information Center
BP-05	Create a Carbon Offset Purchasing Strategy
BP-06	Develop and Apply or Sell Carbon Offsets
BP-07	Offer Voluntary Carbon Offsets for Passengers
BP-08	Use Airport-Specific Sustainable Planning, Design, and Construction Guidelines
BP-09	Participate in a Greenhouse Gas Registry and/or Accreditation Program
BP-10	Set a Policy for Green Building Certification for Buildings
BP-11	Support the Use of Customer Self-Service Equipment in Terminal Design

[16] Transportation Research Board, ACRP Report 56, Handbook for Considering Practical GHG Emission Reduction Strategies for Airports, 2011, http://onlinepubs.trb.org/onlinepubs/acrp/acrp_rpt_056.pdf.

	Construction
CN-01	Use Warm Mix Asphalt (WMA) in place of Hot Mix Asphalt
CN-02	Recycle and Reuse Construction and Demolition Materials
CN-03	Implement a Construction Vehicle Idling Plan
CN-04	Specify Low-emission Construction Vehicles and Equipment
CN-05	Specify Energy Efficient Temporary Lighting During Construction
	Carbon Sequestration
CS-01	Install Sustainable, Long-term Vegetation
CS-02	Add Mineral Carbonation Systems to Exhaust Streams
CS-03	Implement or Support Carbon Dioxide Capture and Storage Processes
CS-04	Invest in Terrestrial Carbon Sinks
	Energy Management
EM-01	Develop a Strategic Energy Management Plan
EM-02	Specify Energy Efficiency Requirements for Equipment in Contract Agreements
EM-03	Develop Energy Performance Contracting Partnerships
EM-04	Enter into a Green Power Purchasing Agreement
EM-05	Evaluate "Take or Pay" Contract Provisions
EM-06	Develop and Market an Energy Conservation Program for Building Users
EM-07	Evaluate Fuel Mix
EM-08	Use Thermal Imaging to Identify Energy Losses
EM-09	Improve Insulation of Building Envelope
EM-10	Change Set Points or Exclude Selected Zones from Heating and Cooling
EM-11	Restrict Heating and Cooling to Lowest 10 feet of Indoor Space
EM-12	Install Green Vegetated Roofs for Greater Building Insulation
EM-13	Install a Cool Roof
EM-14	Design Building Orientation for Energy Use Reduction
EM-15	Apply Solar Reflective Paint
EM-16	Apply Thermo-chromic Coatings on Buildings
EM-17	Install LED Runway and Taxiway Lighting
EM-18	Implement a Lighting System Energy Conservation Program
EM-19	Install a Building Automation System (BAS)
EM-20	Periodically Re-commission HVAC Systems and Control Systems
EM-21	Install High-Efficiency Equipment and Controls
EM-22	Integrate Thermal Storage into Heating and Cooling Systems
EM-23	Evaluate and Upgrade the Central Plant and Distribution System Equipment
EM-24	Install Variable Speed Drives (VSD) and Optimize Controls of Pumps for Air Handling Units
EM-25	Install Evaporative Cooling Systems
EM-26	Install Energy Efficient Chillers
EM-27	Install Ultraviolet-C (UVC) Lights in Air Handling Units (AHUs) for Continuous Coil Cleaning
EM-28	Install a Heat Recovery System
EM-29	Design for Larger Diameter Piping
EM-30	Reduce Transmission Losses in Electrical Wires
EM-31	Purchase ENERGY STAR Equipment
EM-32	Enhance Piping Insulation
EM-33	Construct a Cogeneration or Tri-generation Energy System

EM-34	Use Methane from Anaerobic Bioreactor Treatment Systems for Deicing Fluids
EM-35	Install Energy Efficient Elevators, Escalators and Auto-walks
EM-36	Optimize Passenger and Baggage Handling System
EM-37	Incorporate Use of Natural Ventilation and Economizer Control
EM-38	Install Window Awnings or Sunshades
EM-39	Utilize Sophisticated Energy Models for Building Design
	Ground Service Equipment
GS-01	Support Alternatively Fueled Ground Service Equipment (GSE)
	Ground Transportation
GT-01	Provide Priority Vehicle Parking for Emissions Friendly Vehicles
GT-02	Provide Preferential Car/Vanpool Parking for Employees
GT-03	Promote Public Transit to the Airport
GT-04	Provide Transit Fare Discounts and/or Alternative Mode Subsidies
GT-05	Increase Mass Transit Access to the Airport
GT-06	Alter Parking Pricing Structures for Employees and Passengers
GT-07	Implement "On-foot" Payment for Parking
GT-08	Implement a Traffic Management System
GT-09	Allow Telecommuting for Employees
GT-10	Allow Flexible Work Schedules for Employees
GT-11	Build a Consolidated Rent-A-Car Facility (ConRAC)
GT-12	Construct a Personal Rapid Transit (PRT) System
GT-13	Promote Bicycle Use by Employees
GT-14	Convert Airport Fleet Vehicles to Alternatively Fueled Vehicles
GT-15	Support Conversion of Tenant Fleet Vehicles to Alternatively Fueled Vehicles
GT-16	Support Alternatively Fueled Vehicles for Rental Cars and Commercial Vehicles
GT-17	Support Alternatively Fueled Taxis
	Materials and Embedded Energy
ME-01	Develop an Integrated Solid Waste Management Plan
ME-02	Start or Enhance a Waste Reduction or Recycling Program
ME-03	Start or Enhance a Green Procurement Program (GPP)
ME-04	Separate and Compost Food Waste
	Operation and Maintenance
OM-01	Create a Detailed Operations and Maintenance Manual
OM-02	Develop a Measurement and Verification Plan
OM-03	Use a Computerized Maintenance Management System (CMMS)
	Performance Measurement
PM-01	Conduct Regular Greenhouse Gas (GHG) Emission Inventories
PM-02	Perform Energy Audits
PM-03	Install Tenant Energy Sub-Metering Systems
PM-04	Track Energy Use
PM-05	Work with Airport Industry to Develop Benchmarking Databases
	Renewable Energy (on-site)
RE-01	Install Building Integrated Photovoltaic (BIPV) Panels
RE-02	Install Building-mounted or Ground-mounted Solar Photovoltaic (PV) Panels
RE-03	Install Solar Thermal Systems for Hot Water Production

RE-04	Use Solar Desiccant Air Conditioning Systems
RE-05	Use On-site Biomass Energy Systems
RE-06	Install Ground-Source or Geothermal Heating and Cooling System
RE-07	Install a Geothermal Snow and Ice Melting System
RE-08	Use Seawater and Natural Water Bodies for Cooling
RE-09	Install Building-Mounted Wind Turbines
RE-10	Install a Waste-to-Energy System
RE-11	Install a Tidal Energy System
RE-12	Install Sewer Heat Recovery Systems
RE-13	Construct a Hydrogen Fueling and Generation Station
RE-14	Utilize Local Landfill Gas
Refrigerants	
RF-01	Replace Refrigerants with Natural or Lower Global Warming Potential (GWP) Gases
RF-02	Incorporate Intelligent Fault Diagnosis for HVAC Refrigerant Systems
RF-03	Use Hydronically Coupled Vapor-Compression Heat Pumps
RF-04	Install Microchannel Components and Heat Exchangers

Source: Airport Greenhouse Gas Emissions and Reduction Tool, 2014.

E GHG Spreadsheet-based Tool

A GHG spreadsheet-based tool was developed to enable PHL staff to conduct updates to the GHG emissions inventory. The spreadsheet-based tool consists of 2 worksheets: a data input worksheet and an emissions output datasheet.

The user must populate the input data worksheet (shown in **Figure E-1**) with usage data (e.g., fuel usage, vehicle-miles travelled, etc.) for each airport source included in the emissions inventory (e.g., aircraft, fleet vehicles, stationary sources etc.). Additional modeling (i.e., FAA's EDMS) is required to estimate aircraft, APU, and GSE usage.

Figure E-1. GHG Spreadsheet-based Tool Input Worksheet

PHILADELPHIA INTERNATIONAL AIRPORT
GHG Emissions Inventory -- Inputs (2013)

Source	Fuel	Usage	Units	Category	Scope	Source of Data/Assumptions
Aircraft						
Aircraft Taxi	Jet A	23,191,813	gallons	Tenant	3	PHL Airport Noise and Operations Monitoring System and FAA Tower Counts, EDMS 5.1.4.1.
Aircrat Taxi	AvGas	1,699	gallons	Tenant	3	
Aircraft AGL	Jet A	17,501,710	gallons	Tenant	3	PHL Airport Noise and Operations Monitoring System and FAA Tower Counts, EDMS 5.1.4.1.
Aircraft AGL	AvGas	3,096	gallons	Tenant	3	
Aircraft Engine Startup	Jet A	258,752	gallons	Tenant	3	PHL Airport Noise and Operations Monitoring System and FAA Tower Counts, EDMS 5.1.4.1.
Aircraft APU	Jet A	951,905	gallons	Tenant	3	PHL Airport Noise and Operations Monitoring System and FAA Tower Counts, EDMS 5.1.4.1 and Jet Bridge Inventory.xls.
Aircraft Cruise	Jet A	354,166,670	gallons	Tenant	3	Aicraft Flight - Aicraft Taxi - Aircraft AGL - Aircraft Engine Startup - Aircraft APU.
Aircraft Cruise	AvGas	11,205	gallons	Tenant	3	
Aircraft Flight	Jet A	396,070,850	gallons	Tenant	NA	Fuel Use Data 08-22-14.xls.
Aircraft Flight	AvGas	16,000	gallons	Tenant	NA	
GSE						
GSE (Tenant)	Gasoline	485,141	gallons	Tenant	3	Fuel Use Data 08-22-14.xls.
GSE (Tenant)	Diesel	1,168,914	gallons	Tenant	3	
Fleet Vehicles (Airport)	Gasoline	77,608	gallons	Airport	1	City Gov GHG Inventory 2013- Kate's File (aviation 13vf) and Fuel Use Data 08-22-14.xls.
Fleet Vehicles (Airport)	Bio-Diesel	49,054	gallons	Airport	1	
Fleet Vehicles (Tenant)	Gasoline	32,754	gallons	Tenant	3	
Fleet Vehicles (Tenant)	Bio-Diesel	18,218	gallons	Tenant	3	
GSE - Snow Removal (Airport)	Diesel	101,546	gallons	Airport	1	Snow Billing 2013-14.xls.
Employees-Total	19,611	155,495,583	VMT	Airport/Tenant	1 and 3	Number of total employees. Distance based on Zipcodes.xl (.one-way trip distance of 20 miles for tenants and 14 miles for Airport employees).
Employees-Airport	1,027	5,791,139	VMT	Airport	1	Number of airport employees. Assumed 5 days per week, 50 weeks per year, 28 miles per round trip, 13% use mass transit, 1.08 employees per trip (Employee Trip Reduction Survey Report, June 2011).
Employees-Tenant	18,584	149,704,444	VMT	Tenant	3	Assumed 5 days per week, 50 weeks per year, 40 miles per round trip, 13% use mass transit, 1.08 employees per trip (Employee Trip Reduction Survey Report, June 2011).
Parking Lots (economy, garage parking and short-term) on-airport	Composite	558,527	VMT	Tenant	3	ParkingFacilities_Compiled.xls (assumed 0.25 mile roundtrip) and MOVES (Passenger Car and Truck at 10 mph).
Parking Lots (employee lot) on-airport	Composite	92,500	VMT	Airport	1	

The emissions output datasheet (shown in **Figure E-2**) will then calculate emissions of CO_2, CH_4, N_2O, and total CO_{2e} in metric tons using input usage data, emission factors, and global warming potentials embedded in the datasheet. Emission factors have been populated based on most current available EPA factors. These factors will need to be updated to calculate future years of the GHG emissions inventory. Additional modeling (i.e., EPA's MOVES) is required to estimate mobile source emission factors. The datasheet is currently set to estimate calendar year 2013 GHG emissions.

Figure E-2. GHG Spreadsheet-based Tool Output Datasheet

PHILADELPHIA INTERNATIONAL AIRPORT
Emissions (2013)

Source	Fuel	Usage	Units	CO2 (TPY)			N2O (TPY)			CH4 (TPY)			CO2	N2O	CH4	Total CO2e
				EF	Units	Emissions	EF	Units	Emissions	EF	Units	Emissions	MTCO2E			
Aircraft																
Aircraft Taxi	Jet A	23,191,813	gallons	21.50	lb/gallon	249,255	0.0007	lb/gallon	8	-	lb/gallon	-	226,120	2,073	0	228,193
Aircrat Taxi	AvGas	1,699	gallons	18.32	lb/gallon	16	0.0002	lb/gallon	0	0.01556	lb/gallon	0	14	0	0	14
Aircraft AGL	Jet A	17,501,710	gallons	21.50	lb/gallon	188,100	0.0007	lb/gallon	6	-	lb/gallon	-	170,642	1,565	0	172,206
Aircraft AGL	AvGas	3,096	gallons	18.32	lb/gallon	28	0.0002	lb/gallon	0	0.01556	lb/gallon	0	26	0	1	26
Aircraft Engine Startup	Jet A	258,752	gallons	21.50	lb/gallon	2,781	0.0007	lb/gallon	0	-	lb/gallon	-	2,523	23	0	2,546
Aircraft APU	Jet A	951,905	gallons	21.50	lb/gallon	10,231	0.0007	lb/gallon	0	-	lb/gallon	-	9,281	85	0	9,366
Aircraft Cruise	Jet A	354,166,670	gallons	21.50	lb/gallon	3,806,414	0.0007	lb/gallon	117.120	-	lb/gallon	-	3,453,122	31,662	0	3,484,784
Aircraft Cruise	AvGas	11,205	gallons	18.32	lb/gallon	103	0.0002	lb/gallon	0.001	0.0156	lb/gallon	0.087	93	0	2	95
Aircraft Flight	Jet A	396,070,850	gallons	21.50	lb/gallon	4,256,780	0.0007	lb/gallon	130.978	-	lb/gallon	-	3,861,687	35,409	0	3,897,096
Aircraft Flight	AvGas	16,000	gallons	18.32	lb/gallon	147	0.0002	lb/gallon	0.002	0.0156	lb/gallon	0.125	133	1	3	136
GSE																
GSE (Tenant)	Gasoline	485,141	gallons	19.36	lb/gallon	4,695	0.0005	lb/gallon	0.118	0.0011	lb/gallon	0.267	4,260	32	6	4,297
GSE (Tenant)	Diesel	1,168,914	gallons	22.51	lb/gallon	13,156	0.0006	lb/gallon	0.335	0.0013	lb/gallon	0.734	11,935	91	17	12,042
Fleet Vehicles (Airport)	Gasoline	77,608	gallons	19.36	lb/gallon	751	0.0005	lb/gallon	0.019	0.0011	lb/gallon	0.043	681	5	1	687
Fleet Vehicles (Airport)	Bio-Diesel	49,054	gallons	20.83	lb/gallon	511	0.0006	lb/gallon	0.014	0.0013	lb/gallon	0.031	464	4	1	468
Fleet Vehicles (Tenant)	Gasoline	32,754	gallons	19.36	lb/gallon	317	0.0005	lb/gallon	0.008	0.0011	lb/gallon	0.018	288	2	0	290
Fleet Vehicles (Tenant)	Bio-Diesel	18,218	gallons	20.83	lb/gallon	190	0.0006	lb/gallon	0.005	0.0013	lb/gallon	0.011	172	1	0	174
GSE - Snow Removal (Airport)	Diesel	101,546	gallons	22.51	lb/gallon	1,143	0.0006	lb/gallon	0.029	0.0013	lb/gallon	0.064	1,037	8	1	1,046
Employees-Airport	Composite	5,791,139	VMT	522	g/mile	3,332	0.008	g/mile	0.053	0.0106	g/mile	0.067	3,023	14	2	3,038
Employees-Tenant	Composite	149,704,444	VMT	522	g/mile	86,130	0.008	g/mile	1.358	0.011	g/mile	1.742	78,136	367	39	78,543
Parking Lots (economy, garage parking and short-term) on-airport	Composite	558,527	VMT	876	g/mile	539	0.021	g/mile	0.013	0.018	g/mile	0.011	489	3	0	493
Parking Lots (employee lot) on-airport	Composite	92,500	VMT	876	g/mile	89	0.021	g/mile	0.002	0.018	g/mile	0.002	81	1	0	82